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Main Street, Quogue, L. I.,
a splendid example of a
TEXACO-Oiled surface.

500,000 GALLON ROAD OIL LETTING IN BOROUGH OF BROOKLYN, NEW YORK CITY

Brooklyn, N. Y., Jan. 21.—Today the Borough of Brooklyn held its annual Road Oil letting, the amount of material being 500,000 gallons. This oil is to be used during 1925 in treating earth and similar types of streets in all parts of the Borough.

Contract was awarded to The Texas Company on TEXACO ROAD OIL.

Facts like the following become doubly interesting:—

The towns of Long Island, New York, during past years have used a total of many million gallons of TEXACO Road Oil, obtaining as a result a system of roads which has created considerable favorable comment.

Pennsylvania last year employed several million gallons of TEXACO Road Oil. Its use throughout the rest of the country on earth, sand-clay, gravel, macadam, shell and cinder streets has been very successful.



The smooth, waterproof
TEXACO-Oiled surface of
the West Road to West-
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FEBRUARY, 1925



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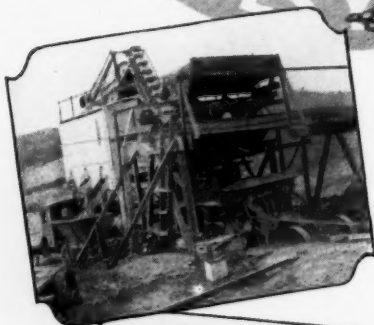
Space won't permit anything like a complete description of the now famous Western-Aurora two-blow stroke, but the coupon will bring you a catalog that tells all about it. What counts is that as a result of this continuous two-blow stroke and freedom from springs and toggles a Western-Aurora Crusher in your plant means:

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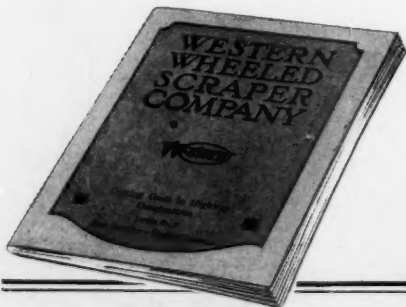
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When choosing a crushing plant, your first thought is naturally of the crusher itself—but elevator, screen and bin are of almost equal importance. This fact is always in the minds of Western engineers, and as a result you will find each unit in the Western-Aurora Crushing and Screening Plant on a par with the crusher, and ready to give you the same standard of service.



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PUBLIC WORKS

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No. 2

Trench Cuts in Pavements

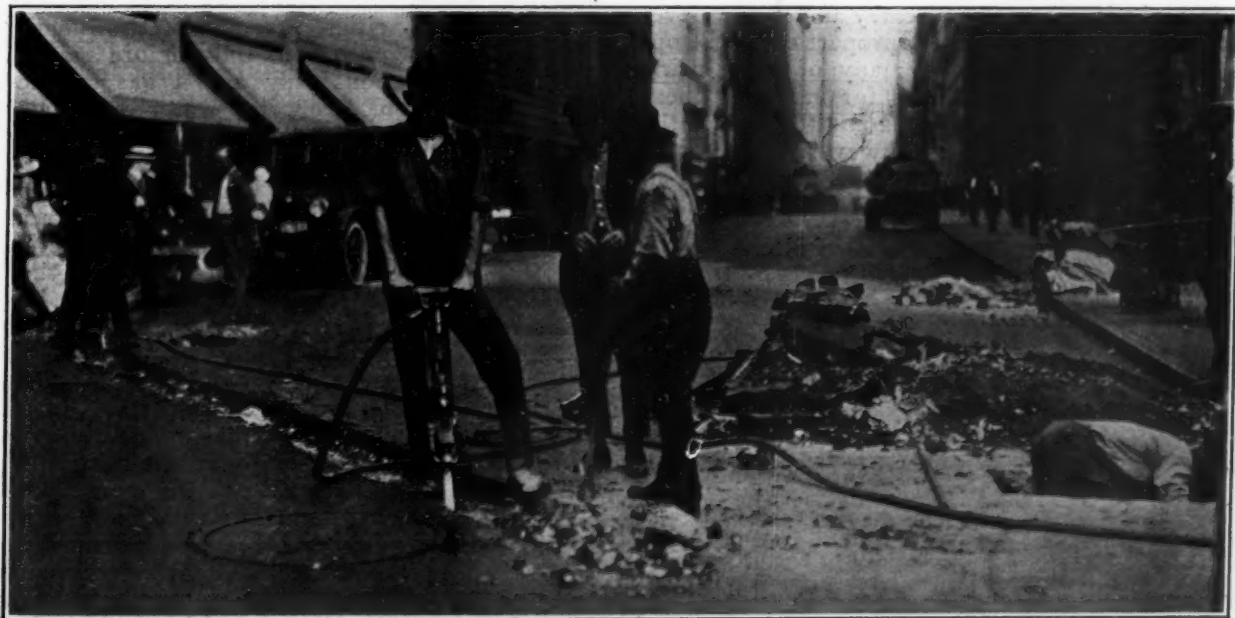
Millions spent every year in repairing cuts made in pavements. Several score city engineers describe the methods employed in their respective cities in an effort to lessen the number of cuts caused by public utility mains and services. Placing mains in sidewalk areas.

In most cities a considerable part of the cost of repairing and maintaining pavements is attributable directly to the cuts made in the pavements from time to time for constructing and repairing underground structures — sewers, water and gas pipes, electric conduits, etc., and connections between each of these and the abutting properties.

In a questionnaire on paving matters sent out in January, more than 500 of which have been returned by city engineers, several questions were asked concerning this matter, one of these being: "How much of the cost for repairing pavements in 1924 was for repairing cuts made for trenches dug to lay or repair mains and conduits and house connections thereto?" About 250 gave definite answer to this question. Of these, 29 stated that no money had been spent

by their city for this purpose in 1924, although some of these said that such freedom from expense of this kind was unusual, while in other cases we believe that expenditures were made for this purpose but by public service companies directly. In fact, 28 gave no cost of making these repairs, but stated that they were made by the public service companies, plumbers, owners, etc. On the other hand, 23 cities reported that all the money spent on pavement repair last year was for repairing pavement over such trenches.

Of those giving figures of expenditures for this purpose, including those who reported spending nothing, the average of such expenditures by all was 28¼% of the entire expenditure for pavement maintenance. Most of these were cities of moderate size, but expenditures by them



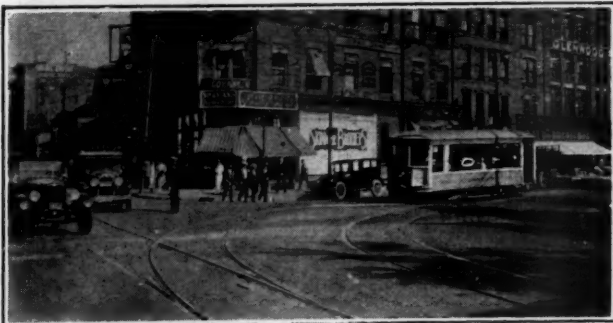
BREAKING UP A PERFECTLY GOOD ASPHALT PAVEMENT FOR SERVICES.
Drilling through concrete base with compressed air on Forty-third street, New York.

of \$1,000 to \$10,000 for trench paving repairs were quite common. Among the larger cities much larger sums, of course, were spent for this purpose. Minneapolis reported \$45,000; Dayton, Ohio, \$20,000; Dallas, Texas, \$30,000. Some much smaller cities incurred considerable expense last year for this purpose, such as \$20,000 by Kenosha, Wis., and \$36,000 by Greensboro, N. C.

A great many of the engineers replying expressed their realization of the importance of the matter and most of them explained the more or less successful methods that had been adopted in their respective cities in an effort to reduce the amount of such repairs necessary.

By far the most common method employed is that of requiring all house connections to be carried from the main to the curb before any durable pavement is laid. Some cities have adopted the rule of constructing sewer connections to the curb, at intervals sufficient to provide for all contemplated users, at the time the sewer is built; while a number also require connections to be run from water mains when these are constructed. Some require that the water services thus carried to the curb shall be built of lead. A few cities require that, before paving is begun on any street, all the existing services in that street shall be replaced with new services, generally of lead, and that anticipatory connections be carried to the curb at intervals generally of about 50 feet.

Another method that has been adopted to a greater or lesser extent by more cities than we had imagined to be the case is that of placing mains in the sidewalk space, generally in the parking between the curb and the sidewalk pavement. This is most common for the water mains and gas mains, but in some cities storm sewers or sanitary sewers or both are so located. Most of the cities following this practice place only one main in a street and carry under the pavement house connections for properties on the opposite side of the street, many of them using pushing or boring machines for installing these house connections without having to cut into the pavement. A few cities, however, place mains on both sides of the street, thus eliminating all connections under the roadway.



INTERSECTION CONTAINING STREET RAILWAYS AND SWITCHES.

This asphalt pavement in Hartford, Conn., was laid in 1908, and, according to deputy city engineer R. J. Ross, has cost an average of 1.6 cents per square yard per year for maintenance in spite of the tracks and switches, which are apparently less injurious than service cuts.

Where cities are laid out with alleys, many of them install sewers and other underground utilities in the alleys. A few have made arrangements with the owners in certain of the newer sections whereby mains are laid in the streets that run in only one direction—those streets on which few buildings face—and branches are run from the mains along the rear lot lines dividing the properties, the house connections being made from these branches in the rear of the property.

Some cities urge or require the use of cast iron pipe for sewer house connections to eliminate the digging up required by the stopping of house connections with tree roots. Several engineers express the opinion that some at least of the cutting into streets could be prevented by more careful planning and more rigid inspection of material and workmanship used for mains and house connections.

Several employ methods calculated to make it to the interest of public service companies to avoid making cuts in the pavements by doing all necessary repairing and construction in each street before durable paving is begun in that street; the incentive being either a financial one, requiring the payment of a large sum for a permit for opening the streets or for repaving over trenches, which repaving must be done by the city; or by adopting ordinances providing that for five years after paving a street no trenches shall be opened therein. This last sounds well, but a majority of the cities that have adopted it find it almost impossible to enforce it. One city reports that each cut so made must receive a special vote of council therefor, but no council has yet refused to vote a permit asked for.

The reports from the various cities relative to the methods employed are summarized in the following paragraphs:

LAYING CONNECTIONS BEFORE PAVING

Laying house connections before paving was reported by 233 cities, in addition to which 7 reported water connections only before paving, 15 sewer connections only and 4 gas connections. In addition, 2 reported water and sewer connections placed every 50 feet before paving and one requires gas connections every 50 feet. A number of these specify that the connections are carried to the property line, but in the great majority of cases we believe that the practice is to carry them to the curb only unless they are to be put into service at once.

Several cities report that any mains that are to be laid in the street must be laid before paving is done, 2 specifying this for water mains, 2 for sewers, 1 for gas and 20 for mains of all kinds; and we believe that the practice is even more general than these figures indicate.

Sixteen require that all existing house connections be renewed, and one that they be inspected and renewed or repaired as may be necessary; while one specifies that sewer mains are to be relaid and 3 that water connections are to be renewed. Nineteen cities require that all water services be of lead, existing ones of other materials being replaced with lead pipe be-



WARNING NOTICE OVER FIFTH AVENUE, NEW YORK.
NOTICE.

This street is to be overhauled and a new pavement laid. Examine and repair all pipes, electric wires, etc., and make such new installations as are necessary NOW. You will not be permitted to make openings for any purpose for at least a year after completion.

Joseph Johnson, Commissioner of Public Works.
Julius Miller, President Borough of Manhattan.

fore the paving is begun. Four specify generally that all underground work required in the street shall be completed before paving and two that all general repairs shall be done. In three cities all sewer connections are carried to the curb when the mains are laid, and are, therefore, in when paving is done, while the same is true of water connections in two cities. One city specifies that valves as well as mains are gone over and renewed if necessary before paving. In one city mains and house connections not already in the street are laid as part of the paving contract. In another, house connections must be installed one year before paving is begun.

LOCATING MAINS OUTSIDE OF ROADWAY

The plan apparently second in popularity for minimiz-

ing cutting into pavements is placing the mains outside the roadway pavement, generally in the parking of the sidewalk area. Twenty-two report placing watermains in the parking, 16 main sewers, and 18 gas mains, while 23 use this space for mains without designating what kind. In addition, 22 report laying mains in the sidewalks, without specifying the parking. Telephone conduits also are so located in one city and steamheating mains in another.

Alleys are used in a number of cities, five reporting this location used for mains generally, 11 for sewer mains, 6 for watermains and 5 for gas mains. In five cities arrangements are made for laying mains along the rear lot lines and thus serving the abutting properties from the rear, this applying generally to certain of the newer sections only and, of course, only to those where alleys do not exist. One city, just before paving the street, removes from the roadway any mains that may have been laid there.

OTHER PRACTICES

In Creston, Ia., where excavations must be made for tapping mains or laying or repairing house connections, this is done as far as possible by tunnelling and the tunnels are backfilled with cinder concrete mixed 1:10. In Newton, Ia., also, house connections that need to be laid after paving are done by tunnelling to the main from the parking. Marion, Ohio, tunnels where possible in reaching services under pavement and fills with crushed stone where the pavement is on a concrete base and with concrete where it is on a stone base.

Quite a number avoid cutting the pavement in carrying house connections under the roadway by using pushing or boring machines, or some by using the water jet, the latter being used apparently only in sandy soils. Some special methods are described elsewhere in this issue.

In order to discourage cutting by public service corporations, four make heavy charges for issuing permits for cuts; while eight report



RESULT OF THE WARNING NOTICE.
Putting underground structures and appurtenances into shape before paving.

that no cutting is permitted for five years after pavement is laid, four others setting this period at three years and two at two years. In Water-
loo, Ia., the ordinance forbids cutting a pave-
ment for two years after it is laid and for the
next five years provides for a charge double
that required for older pavements.

SUGGESTIONS OFFERED

In our questionnaire, city engineers were re-
quested to offer suggestions of methods that
they would recommend but that were not prac-
ticed in their own cities. The majority of the
recommendations were for certain of the meth-
ods above described, which presumably had been
learned of by the writers' investigations of other
cities. Where this was the case, such recom-
mendation should probably carry more weight
than the statement that a certain plan is used
in a given city or cities, since there is generally
no indication in the latter case as to the satis-
factoriness of the practice.

Of the suggestions, that of putting mains in
parking strips was apparently most popular,
this being recommended by fifteen cities ex-
tending from the extreme north to the extreme
south and of widely varying sizes. The second
largest number of recommendations was for
placing all mains in alleys. One recommends
placing the mains in the roadway but near
enough to the curb so that they can be reached
by tunnelling from the parking when house
connections are to be laid or repaired. Two
cities recommend that mains be placed in the
parking on each side of each street on which
houses face, but only one main in those streets
which pass along the sides of the properties or
on which few houses face.

Several recommend more care in the original
construction of mains so as to minimize the
necessity for future repairs with resulting pave-
ment cuts, requiring all public utilities to bring
their properties to such a standard that they
will outlast the pavement. Several would in-
sist on more careful supervision of underground
construction by municipal inspectors and engi-

neers. Insisting that all water services in a
street be of lead before paving is begun is
recommended by six. Lyons Mussina of Wil-
liamsport, Pa., reports that where this has been
practiced in Williamsport since 1918, not a single
cut for repairing services has been made. Pre-
venting freezing by putting watermains deeper,
and the use of cast-iron pipe for sewer connec-
tions are other suggestions.

Some of the other recommendations are to
carry connections to curb or property line when
main is laid, to renew all services before paving,
to use a pusher or borer for placing the service
under a paved street. Several would refuse per-
mits for openings for a series of years after
paving, or make heavy charges for permits for
cutting into a pavement. One engineer would
defer laying a pavement until the property has
been developed and mains and house connec-
tions laid, in the meantime maintaining the road
with tar macadam. Another would place gas
and water connections in tile conduits. (This
method is described elsewhere in this issue.)
Another suggestion is to put extra pressure
on the watermains to discover weak places and
remedy these before paving the street.

Mains in Sidewalk Areas

So many engineers reported or advocated the
laying of mains in the sidewalk area that special
inquiries were sent to cities where it was learned
that this was practiced with a view to obtaining
more detailed information. The replies received
to these inquiries will be summarized in the
following paragraphs.

In about two-thirds of the cities where mains
of various kinds are laid under the sidewalk
they are located on one side of the street only,
so that house connections have to be carried
from them under the roadway to reach the
houses on the opposite side of the street. In
these cases the object was either to permit lay-
ing the main in streets that were already paved



PREPARING FOR PAVING IN A NEW JERSEY SUBURB.
Gas service trenches excavated across roadway. B. G. ditcher (in line with horse shed)
digging a third service trench.

without cutting into the pavement and at the same time make the main accessible for repairs, or, where the pavement had not yet been laid, to make it possible to reach the main for tapping for house connections without breaking into the pavement. Water mains were reported laid on one side only in 14 cities and on both sides in 5; gas mains on one side in 9 cities and both sides in 7; sanitary sewers on one side in 4 cities and both sides in 4; storm sewers on one side in 7 and both sides in one; and electric conduits on one side in 2 cities and both sides in one.

MAINS ON BOTH SIDES

Five cities reported at some length concerning the laying of mains on both sides of the street. H. A. Rowland of McPherson, Kans., says that in the business section a 6-inch water-main is laid about 3 feet back of each curb and from these mains service connections are taken off in pairs in manholes, making the corporation cocks always accessible. The short service and accessibility result in considerable saving. In residence sections a main is similarly located on one side of the street only.

In Newton, Mass., says William P. Morse, Commonwealth Avenue, 120 feet wide, is the only street with mains on both sides. This was done as a matter of economy in length of services and cutting of expensive road pavement. Since then a 40-inch and a 60-inch water main have been run through the center of the street making this construction almost necessary for other utilities also, and the sewer is placed from 3 to 4 feet from each property line, the water main 6 to 8 feet and the gas main 10 to 13 feet. The sewers are generally 8-inch diameter, the water and gas each 6-inch. With the mains inside the curb it is, of course, impossible to place the cutoff boxes at the curb line, as is customary, and they are placed at or close to the property line.

George C. Finch writes that in Greensboro, N. C., sewer and gas mains in the residential district are located between the curb and the sidewalk pavement, but the water main is placed in the street. As a rule a 4-inch gas main and a 6-inch sewer are laid on each side. "The cost of two lines as compared to one line in the center in some ways is more and in other ways less. As a rule, however, we find it an economical practice to lay two mains in preference to

one, particularly in new suburb developments."

In Elyria, Ohio, the standard practice, according to J. M. Powell, is to lay sanitary sewers in the center of the street, storm sewers, water and gas mains preferably between curb and the tree line. This practice was introduced originally when extending mains into streets that had already been paved and is employed in both business and residential districts. The gas mains are laid 2 feet deep, water mains 5 feet, sanitary sewers 6 feet and over, storm sewers 4 feet and over and telephone conduits 2 feet. The cutoff valves are placed in line with the trees. The sizes of main used on the two sides of the street are not necessarily the same, but water mains are ordinarily either 6- or 8-inch, gas mains from 1½ to 6 inches and sewers 6 inches and over. As to relative costs, these vary, depending on depths of mains, length of service connections, etc. "As a general rule, when investment in service connections and all factors are considered, we believe there is very little difference in the costs of the two methods; in some cases the two-main method will be found more economical." Among the disadvantages of this practice might be mentioned the insufficient space for all the mains in the parking on some streets and the great difference in length between service connections to opposite sides of the street.

In Zanesville, Ohio, the practice of laying two mains has been confined so far to four streets where sewers are being laid as part of a system of 24 miles now under construction; these four streets having been already paved. An 8-inch sewer is placed on each side of the street from 2 to 8 feet inside the curb, the 8-foot distance being between the sidewalk and the property line. The sewers run from 6 to 9 feet deep. This construction costs about 52% more than laying one sewer in the center of the street with a 6-inch connection carried to each curb line.

In Portland, Ind., the gas company places the pipes between curb and sidewalk, generally on one side only, but occasionally on both sides.

In Wichita, Kans., conduits for electric wires and for special whiteway and sign lighting are commonly placed immediately behind each curb. Says Mr. Brockway: "There is an occasional encroachment of basement area up to the curb



LAYING SEWER IN SIDEWALK PARKING IN WICHITA, KANSAS.

54-inch sewer in new development. Completed road way pavement covered with earth from excavation. After sewer had been completed the sidewalks were laid and trees planted

line and the electric lines are carried through these open spaces through metallic conduits suspended on the basement walls."

In Marion, Ohio, the gas company is relaying all its mains in streets that are being paved, placing a smaller line in the parking on each side of the street in the residence districts. In some streets in the business districts new mains are laid in each gutter.

C. L. Orr writes that Worcester, Ohio, has, during the past two years, endeavored to get into the sidewalk area in the residential districts all of the underground conduits except the sanitary sewers. In general there is a 7-foot parkway and a 5-foot concrete or flag walk. In the parkway water mains are placed near the curb, usually a 6-inch main on one side of the street and a 2-inch main on the other side. The gas and telephone companies lay their lines approximately 2 feet below the surface on one side of the street, preferably the one carrying the larger water main. The only difficulty encountered is the installing of hydrants and hydrant shutoff valves in the 7-foot parking space. Gate valves are placed at all four points of each street intersection just outside of the curb radii. The first cost is somewhat higher than a single line in the center of the street, but the difference in length of services helps to compensate for this and the satisfaction of not having to replace a newly paved street makes up the difference.

In Dubois, Pa., the gas company now follows the practice of laying a main on each side of the street.

W. L. Dunn writes that in Uniontown, Pa., wherever possible they are now placing sewer, water and gas mains between the curb and sidewalk in the residence section, but not in the business section where there is no parking. Gas mains have been placed on both sides at little greater cost than one larger main in the roadway. On hillside streets one line of sanitary sewers is run between curb and sidewalk on the high side to serve the houses of that side, while those on the low side of the street are served by a second sewer run through the alley at the rear of these houses and lower down the hill.

MAINS ON ONE SIDE ONLY

In Longmont, Colo., says Edwin S. Bice, the streets in the original town are 100 feet wide with curb lines 25 feet and 27½ feet from the property line. This leaves a wide parking in which the water mains are generally laid. Most of the sewer mains are laid in alleys; where they are laid in streets, all connections are usually made before paving. Mr. Bice thinks that it is cheaper to lay water mains on one side only and carry connections entirely across the street, than to lay a main on each side. In main street, where there are only 16-foot sidewalks, when laying the concrete roadway pavement a longitudinal joint was constructed one foot to one side of a line directly over the center of the main, so that in case it should become necessary to cut the pavement to reach

the mains for repairs, etc., this joint would come at one side of the trench. Here all connections to the main had to be made with lead pipe prior to paving.

In LaGrange, Ga., the practice was adopted recently, writes G. H. Sargent, of placing water and gas mains, sewers, etc., in the sidewalk area, although most of the old ones were placed under the roadway. The streets are so divided as to give a width of sidewalk area of 15 to 18 feet, except in Broad street where there is 25 feet on each side. Before putting in improved paving, new water mains are laid in the parkway about 2 feet from the curb, and for serving houses on the opposite side of the street a 1¼-inch lead-lined service is run and branched so as to serve four properties, thus making only one long service across the roadway instead of four. The same method is followed in laying gas mains, the gas main being on the opposite side of the street, but it is necessary to run a separate service pipe for each house, galvanized pipe being used for the long services. Storm sewers are laid on the same side of the street as the gas main. Sanitary sewers are laid in the center of the street.

In Elkhart, Ind., the water and gas mains are laid between curb and sidewalk as much as possible and the sewers in the roadway. H. J. Weaver writes that the water mains are laid as near the sidewalk as the trees will permit. The gas main is laid on one side and the water main on the other, one purpose of this being to equalize the costs of the services to the property owners, who pay for the entire service from the main in both cases.

Mr. O. O. Clayton states that in Portland, Ind., sewer mains and laterals are laid between the curb and the sidewalk in all new construction, the cost of this being found to be appreciably less than laying in the center of the roadway.

P. L. Brockway, city engineer of Wichita, Kans., states that that city is platted very largely with alleys for the various utilities and to permit rear-door service; or, if there are no alleys, the city requires an easement on the rear of the lot for the utilities. The telephone company and electric power and light company have a joint agreement to use each other's poles on a rental basis, these poles being placed in the alleys or easements, keeping the streets and front lawns free from the unsightly encroachment. Sanitary sewers are almost invariably in the alleys or easements. Storm sewers are, however, almost always located in streets, both in order to take care of street drainage and also to prevent confusion in connecting sanitary and roof water house connections respectively with the sewers. In the business district it is the practice to place storm sewer laterals in the alleys for down-spout connections. Gas mains are placed in the alleys wherever possible; where there are no alleys they are placed well out into the street so that leaking gas will not affect the shade trees. (Gas lines laid approximately

15 years ago are in such poor condition that 80% of all pavement cuts in the city during the past year were for repairing and replacing old gas mains.) In making service connections to mains already laid under pavements, a hole about a yard square is cut in the pavement over the main for making the tap and opposite it a hole is dug in the parking space and a steel pipe forced from this underground to the opening at the main. This pipe is large enough to permit the lead pipe (which material is required for services) to be pushed through the rigid pipe. Storm water lines are placed in the parking where possible, some as large as 6 feet internal diameter having been so constructed. Large sewers are, of course, not placed adjacent or too close to large buildings or open basements. The alleys are becoming so crowded underground that it is difficult to find room for the electric conduits, and it has not been found expedient to place them behind the curb in the sidewalk area because of private interests in basements, etc., and they will be placed a short distance away from the curb on one side of the street at locations selected so that transformer stations may be installed in the basement areas with a minimum amount of destruction of pavement.

In Newton, Mass., in the sparsely settled districts where there are substantial improved roadway pavements and unimproved earth sidewalks, new water main extensions are being placed in one of the sidewalks to save expense of cutting up pavement.

In Winchester, Mass., writes James Hinds, in streets where the pavement is of a permanent or semi-permanent character, the sidewalk area has been used for gas mains, storm sewers, electrical conduits and in a few cases for sanitary sewers, this being the practice in both business and residential districts.

In Holland, Mich., sanitary sewers are laid 19 feet from the property line on the south and west sides of the streets and the watermains 19 feet from the opposite property line. These distances bring the mains under the curb line on most of the residence streets. The storm sewers are laid 15 feet from the property line, which brings them in the parking.

In Jackson, Mich., water mains are placed between the curb and sidewalk; all gates are located just outside of the street intersections and service boxes at the edge of the sidewalk nearest the curb line. Services are run under the roadway through the sandy soil by the aid of water jets, this requiring about 20 minutes after the hole has been dug outside the pavement.

Laying water mains between curb and sidewalk in Brainerd, Minn., began years ago when kalamein pipes were used. The streets were laid out 80 feet wide and the mains located a standard distance of 22 feet from property lines. Years later, when 30- to 35-foot pavements were laid, the curbs were located more than 22 feet from property lines in the residence districts,

but in the business districts where roadways are 50 to 70 feet wide the curbs were placed 5 to 8 feet outside the mains. Later, when new mains were laid these were placed in the side parking on one side, services being jetted through the sandy soil under the pavements. They were laid about 3 feet from the curb, thereby avoiding poles on the one side and trees on the other. Because of frost, they are laid about 8 feet deep. Valves are placed on the property lines of intersecting streets. Service valves are located about a foot from the sidewalk. Gas mains are placed generally in alleys; where in the street, they are kept at least 5 feet from the curb to avoid damage to trees from leaking gas.

Johnson City, N. Y., places storm sewers under sidewalk space where the roadway is paved, it being about \$3 per square yard cheaper to replace the sidewalk than the pavement. Only one sewer is used in a street, catchbasins on the other side being connected across the roadway.

In Marion, Ohio, in very wide streets having a parking down the center, sewers are laid in the sidewalk parking on one side. In one such street a water main was laid in the middle parking.

In DuBois, Pa., before paving a street, the water main, if not already laid, is placed on one side of the street and all service lines to properties on the opposite side are constructed.

In Wilkesburg, Pa., mains of all kinds are placed between curb and property line on one side and connections to the other side made by boring under the roadway, which is 20 to 30 feet wide between curbs. Most of the streets are higher on one side than the other, and the sewers are located 4 feet from the lower property line, giving just room enough to construct manholes without encroaching on the property. This reduces the depth of sewer necessary for draining the property on the lower side of the street, and as a result the possibility of striking rock. In connecting the sewer to houses on the upper side of the street, a house connection is run across for every two lots, to which the two properties connect at the property line.

In Rapid City, S. D., most of the streets are 100 feet wide and the water mains are placed 30 feet from the north and east street lines and the gas mains 30 feet from the opposite sides of the streets. Plumbers use augers to bore under the pavement for cross connections.

In Johnson City, Tenn., storm sewers are laid under or directly back of the curb and gas mains in alleys. Water mains are laid half-way between the curb and the sidewalk where there is a parking at this point. Where there is no main in the street at the time the pavement is laid, services are laid across the street before paving and attached to the main later when it is installed.

In Lynchburg, Va., water, sewer and gas mains are laid in the parkways. Where these are from 6 to 12 feet wide and contain no trees

and it is not too steep, the mains are placed as near the sidewalk as is practicable; this being to keep as far as possible from trees that may be planted and also as far as possible from the curb to provide for future widening of the roadway. Connections are laid in anticipation before paving, but mains are not necessarily so laid where parkways are available. Director R. W. B. Hart writes: "We have not had occasion to disturb, so far as I know, any of our 16½ miles of newly constructed and reconstructed streets in the last four years on account of omissions or neglect in proper sub-surface installations, nor do we anticipate the same for several years to come."

TREES IN PARKWAYS

The existence of trees in parkways in some cases interferes with or renders more difficult the laying of mains in this space, and there would seem to exist the danger that in constructing the main by or under such trees, they might be damaged. A question concerning this was included in the questionnaire. Most of those replying stated that they found little difficulty from trees in installing the mains and no injury to the trees resulting therefrom. In a number of cities this plan of installing mains in the sidewalk space is comparatively recent and confined to extensions in newly developed districts, and in many such instances the shade trees had not yet been planted and thus this problem did not present itself.

Some engineers gave a few words in explanation of their practice in this respect. G. H. Sargent of LaGrange, Ga., says that when small roots are encountered, they are cut, and in the case of large trees, a tunnel is carried under them. James Hinds reports that in Winchester, Mass., roots of trees interfere with trenching, and it has been necessary to mutilate the root system severely in many cases. Roots cut are sealed over, and he has not yet observed any serious results. Jacob Znidema of Holland, Mich., says that a few roots are cut in laying the pipes, but the trees apparently are not injured thereby. W. L. Dunn of Uniontown, Pa., finds no damage to trees or shrubbery resulting from parkway trenches or any disadvantages that are not more than offset by the advantages.

C. R. Spencer of Zanesville, Ohio, tunnels beneath trees or roots of trees that come in the line of the trench and has found this tunneling to have damaged but one tree, this being one that had been set out only a year. H. Snell states that in Midland, Mich., when, in trenching in the sidewalk space, he encounters a number of shade trees, he tunnels under the roots and then, caulking together two or three 12-foot lengths of pipe, slides them through the tunnel. The pipes are laid with not less than 6 feet fill. M. E. Milliren of DuBois, Pa., also tunnels under the shade trees, with no apparent injury to the trees. In Lynchburg, Va., R. W. D. Hart does not attempt to lay mains where trees are likely to give trouble or make the trenching

costly, but under such circumstances lays the mains under the pavement.

The difficulty frequently encountered in cities from the roots of trees entering joints of sewers apparently is not much more serious when the sewers are laid in the sidewalk area, only two engineers referring to this. William P. Morse reports that in Newton, Mass., roots give trouble with some old cement jointed sewers, but not with those laid with the sulphur-sand joint that is now standard practice. Charles F. Sperling states that in Wilkesburg, Pa., there was much trouble several years ago from the clogging of sewer mains as well as house connections by the roots of poplar and willow trees. The borough officials ordered the removal of all poplar and willow trees on the streets of the city or within 100 feet of a sewer, and the street commissioner cut down all that were not removed by the property owner. Since this was done, about ten years ago, no case has come to the attention of the officials of any sewer or house connection being stopped by trees.

Patching a Concrete Road

W. R. Eccles, district engineer, describes in the New Mexico Highway Journal the method employed in patching with concrete a concrete road about three years old. The road had been subjected to unusually heavy traffic, a recent census showing that from 800 to 1,000 automobiles and from 50 to 75 solid-tired trucks per day pass over it. The pavement was constructed 16 feet wide and 6 inches thick, but was recently widened to 19 feet by placing a concrete header or shoulder 1½ feet wide and 9 inches thick on each side of the pavement.

Following the widening, defective places were repaired, most of which had been patched with a mixture of asphalt and sand. There were about thirty of these defective places varying in sizes from 6 square feet to 75 square feet, and in addition six slabs each 30 feet long had developed cracks and holes to such an extent that it was deemed advisable to entirely replace them. On removing the old concrete it was found that in three places the failure had evidently been due to allowing dirt to get into the sand; two corner failures were caused by improper drainage of the subgrade, while the other failures were caused by the settlement of the subgrade.

For the smaller patches the concrete was removed by breaking with sledges and prying out with bars, the ragged edges then being knocked off and the upper edges of the old pavement chiseled down perpendicular for about 1 inch below the surface. Where the broken pieces had been forced down into the subgrade no attempt was made to refill the sunken places with earth, but the entire hole was refilled with new concrete flush to the surface of the pavement, the average thickness of these patches being about 7 inches.

In replacing entire slabs, the old concrete was removed with the aid of dynamite. A charge of

five sticks of 40% dynamite was placed on the concrete and covered with adobe mud, on top of which was placed a heavy rock or old piece of concrete. The explosion tore a hole 12 to 15 inches in diameter and broke the slab radially in all directions, so that sections of from 30 to 50 square feet could be removed by hand with the occasional use of a bar. Where no rock was placed on top of the adobe, the concrete was not broken radially beyond the 12- to 15-inch hole. This method required about 1.2 pounds of dynamite per cubic yard of concrete removed. The average cost of removing slabs with dynamite was \$2.18 per cubic yard, including dynamite, caps and fuse. The average cost of removing the small breaks was \$5.80 per cubic yard.

To minimize the inconvenience caused by closing the road to traffic while the concrete was

curing, this was hastened by use of calcium chloride. An average of 1.6 pounds of calcium chloride to 100 pounds of cement was used, the calcium chloride first being dissolved in twice its volume of clear water and two quarts of the solution added to the concrete for each bag of cement used. It was necessary to float the concrete as fast as poured and, in fact, with the small mixer used, it was impossible to use a template or belt for striking off the finished surface on account of the quick hardening. Within 72 hours after the concrete was laid it was opened to traffic of heavy solid tired trucks. In two instances automobile traffic broke through barricades during the night following the pouring, without injury to the pavement. Mr. Eccles believed that by using a 2.4% mixture of calcium chloride all ordinary traffic could pass safely over the concrete at the end of a 24-hour period.

Brick Paving in St. Petersburg

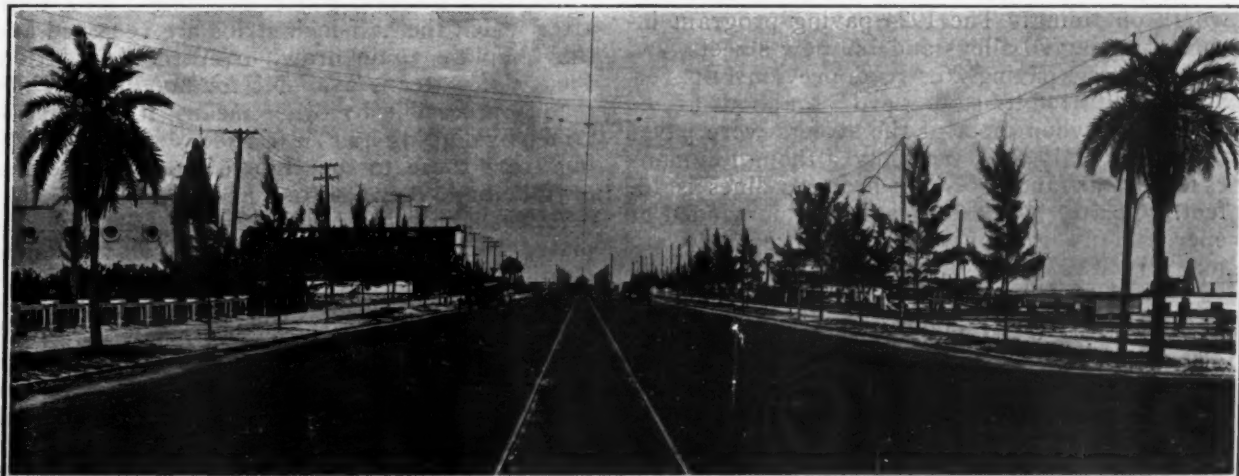
More than one hundred miles of brick pavement laid on the natural sandy soil, without any artificial base. Narrow brick roadways widened, relaying brick after years of use

St. Petersburg is a resort city on the west coast of Florida with a normal all-year population of 30,000 and an estimated winter population of 100,000. The growth has been very rapid recently, the 1900 census showing 1,575 population; the 1910 census, 4,127, and the 1920 census, 14,237. The building permits jumped from \$2,000,000 in 1920 to \$7,000,000 in 1923 and nearly \$12,000,000 in 1924. Since 1920 postal receipts have nearly doubled. Assessed property valuation jumped from about \$16,000,000 in 1916 to more than \$68,000,000 in 1924, and during those eight years bank deposits increased nearly ten times and bank resources nearly eleven times.

As a result, and undoubtedly also as a cause,

of this phenomenal growth is the well-organized enthusiasm of every citizen, from the lowliest newsboy to the bank presidents. With this growth it has been necessary, of course, to spend large sums on public improvements. The city is spending approximately \$100,000 for a white-way street-lighting system seven miles long which will extend well beyond the city's present thickly populated area. A harbor improvement program will entail an ultimate expenditure of nearly \$26,000,000 and half a million dollars was spent on it in 1924. In addition to this whiteway, parks and other attractive features have been developed by the expenditure of large sums.

Along with the more ornamental features,



SECOND STREET, ST. PETERSBURG; WIDENED FROM 30 FEET TO 60 FEET.

the practical has received attention. One million dollars was spent on sanitary sewers and half a million dollars on storm sewers in the year 1924, and during the same year 500,000 square yards of brick pavement was laid, and it is hoped to lay 750,000 during 1925. Large as these figures are, they become additionally impressive when it is understood that the property owner in that city pays the entire cost of street improvement, the city assuming no part of it except that of the engineering. Visitors from northern cities, where a third or a half of the cost is borne by the city and even then council meetings are sometimes overwhelmed by property owners objecting to the paving of their streets, are often surprised to learn that in St. Petersburg hardly a day passes without one or more delegations calling on the city officials to demand that their street be included in the next paving program—entirely at their expense.

Privately owned public improvements show equal confidence and enthusiasm. In addition to a million-dollar theatre and \$300,000 coliseum recently completed, a toll bridge was opened in November, 1924, six miles long connecting St. Petersburg with Tampa on the mainland, which bridge reduces the distance between these cities by 24 miles. This was promoted by George S. Gandy and is known as the Gandy Bridge. This bridge is of concrete construction with four miles of brick paved approach on the St. Petersburg end and one mile of similar approach on the Tampa end.

At the beginning of 1921 St. Petersburg had 50 miles of streets. Today it boasts of more than 108 miles of brick pavements. Two paving companies hold contracts for brick paving this year, the Georgia Engineering Company and W. J. Overman. The former company in one month laid 78,000 square yards of brick pavement, and maintained an average of between 50,000 and 60,000 square yards a month for eight months of the year 1924, according to York Bridell, the superintendent of the company. These figures are impressive when it is understood that a northern contractor considers 50,000 to 100,000 square yards as a good year's work and a contract well worth obtaining. The 1924 paving program included paving 70 alleys and 129 new streets, and widening and paving 26 streets previously paved. The city started its paving program about fifteen years ago, when most of the streets were paved to a width of 15 to 20 feet only, although in many cases the distance between property lines is 100 feet. Greatly increased traffic has demanded an energetic program of widening and repaving, and many roadways are being increased to a width of 50 and 60 feet.

All new brick pavement in residential districts and allotments is of the sand-filled type. The object of this construction is not economy, but with the idea that a few years hence, if rapidly increasing traffic shall demand it, the streets can be widened and the old brick used over again without unnecessary difficulty. When the streets

are widened, or in all cases where the roadway is made as wide as the property lines will permit, asphalt filler is used. In all cases granite curbing is specified because it can be lifted when widening becomes necessary and reset at the newly established line without damage or waste, as can be done with the brick.

The first brick pavement in St. Petersburg was laid in 1904 on Central Avenue, the main business thoroughfare, between 4th and 5th Streets. It was laid on the natural sandy soil and has carried very heavy traffic; trucks loaded with pine logs and weighing between 10 and 15 tons are not uncommon sights on the principal traffic streets. This first piece of pavement is still in service and in excellent condition, according to Ernest Kitchen, director of public works. The cost of this first pavement was approximately \$1.55 per square yard. Today the cost of brick alone is \$1.52 per square yard and the cost of the entire pavement frequently runs in the neighborhood of \$3.16.

CONSTRUCTION OF PAVEMENT

Practically all of the brick pavements in St. Petersburg, as well as throughout Florida generally, are laid on the natural sandy soil without any artificial base. The soil in St. Petersburg is a fine grained, washed beach sand which varies somewhat as to size and shape of grain throughout the city, its treatment for pavement foundation purposes varying accordingly.

The general method of construction is as follows: The street is rough graded and whenever clay, muck or similar soils are encountered, they are excavated to a depth of at least 2 inches below the grade established for the sub-base and replaced with sharp sand brought to the established sub-grade and properly rolled. The grading is paid for at a unit price per cubic yard in place, which is considered equal to 1.15 cubic yards of loose material. One-half inch strips are then laid on the curb and on the guide timbers or rail and a template running on them is drawn over the subgrade, which is then flooded with water and allowed to stand 12 to 24 hours depending on the character of the sand. It is then rolled with a steam roller weighing 5 to 7 tons, after which the half-inch strips are removed and the template again drawn over the foundation. Plenty of water is available for flooding. If not readily accessible by other means, it can be obtained by digging holes a few feet deep and pumping from these to the right-of-way, St. Petersburg being a very few feet above sea-level.

After having been rolled and shaped by template, the subgrade is covered with a sand cushion not less than $\frac{1}{2}$ -inch nor more than 1-inch thick, the cushion material all passing a $\frac{1}{4}$ -inch screen. This cushion is then shaped by means of a template, having first been dampened and rolled with a hand roller weighing not less than 10 pounds per inch of width. The brick is then laid directly upon the sand cushion. In some particularly low spots it has been found necessary to introduce an elaborate system of

tile drainage, both lateral and longitudinal drains being installed.

Where artificial foundation is desired by the engineer, the specifications provide for either a shell or rock foundation. The former is composed of shells spread in two layers of equal depth, each layer being rolled, the total foundation having a thickness of 6 inches. Where the so-called rock foundation is used, the material employed varies in consistency from solid rock to wet marl, no particle having any dimension greater than $2\frac{1}{2}$ inches. This is applied and rolled in the same manner as the shell foundation.

Where sand filler is used, the sand is swept into the joints with brooms until they are completely full, after which the surface of the pavement is covered with clean sand to a depth of $\frac{1}{2}$ -inch. When asphalt filler is used, the construction is similar to that of standard construction for the use of that material.

In connection with widening and paving of old brick streets, Director Kitchen reports practically 100 per cent. salvage value of the old brick. In taking up and relaying old brick, which are of the 3-inch by 4-inch by $8\frac{1}{2}$ -inch repressed type, no effort is made to keep them separate from the new brick, but old and new are relaid in the street just as they come, the wear on the old brick after fifteen years' service being so slight as to be unnoticeable.

Director Kitchen reports that during 1924 the eleven men employed in the Street Maintenance Department were kept busy on ditches, bridges, culverts and cutting trees because there was not sufficient paving maintenance necessary to occupy all their time. The 1924 budget provided \$11,687 for street repair work, and of this only \$600 was for maintenance of the 108 miles of brick streets. Mr. Kitchen reports that no maintenance was necessary on any of the brick streets except over service cuts.

Pasadena's Municipal Electric Plant

The seventeenth annual report of the Municipal Light and Power Department of Pasadena, Cal., would seem to demonstrate that this plant has been unusually successful for a municipal plant, from a financial point of view and apparently from that of service to the citizens as well. C. W. Koiner, who is now city manager, is continued as general man-

ager and electrical engineer of the department which he has served so well for many years.

The fiscal year ending June 30, 1924, was an unusually successful one. The commercial light receipts increased $19\frac{1}{2}$ per cent over those of the previous year, the power receipts $43\frac{1}{2}$ per cent, the gross receipts 24.2 per cent and the net receipts 37.3 per cent.

In making his financial statement, Mr. Koiner calls attention to the fact that depreciation has been written off in a liberal manner, the depreciation last year having been set at \$147,788, while the book value of the plant was \$2,786,010. The depreciation was, therefore, a little more than 5 per cent on the total valuation. Interest was charged at $4\frac{1}{4}$ per cent on the total investment in the property. The accounts are kept in accordance with the requirements of the railroad commission of the State of California. In comparing the finances of this municipal company with those of private corporations of the same character in the State, there is also taken into account the taxes that would have been paid if the plant had been a private company, which taxes would have amounted to \$113,607. Moreover, the maximum rate charged is 5c. per k.w.h., which is less than in the neighboring cities, the statement being made that, had the rate been the same as was charged in those cities (except in Los Angeles), the income would have been increased by \$250,135.

Making all of these allowances, the figures show a surplus of \$397,223 if no allowance be made for taxes, or \$183,616 deducting the taxes for comparison with private companies. These figures show a net earning on the depreciated value of the property of 10.88 per cent.

The department furnishes street lighting, from which it received from the city last year an average of 3.936c. per k.w.h. The average for residence and commercial lighting was 4.66c. The city sells electrical energy to the Southern California Edison Company, this amounting to nearly 7,000,000 k.w.h. per month, or about 60 per cent of the plant's output.

During the past year the department completed a new plant, including a 50-ton crane and a 12,500-k.v.a. steam turbine and two 1,000-horsepower and two 850-horsepower water tube boilers, with a steam pressure of 250 pounds per square inch carrying 150 degrees superheat. The department is expecting this year to place underground a certain amount of its distribution system, and to add to this year after year, with a view to ultimately eliminating all poles. The plant now consists of 680 boiler-horsepower in B. & W. boilers, 2,298 boiler-horsepower in Stirling boilers, 2,850 boiler-horsepower in Connolly boilers, 1,900 horsepower in cross compound condensing engines and 18,100 horsepower in Parsons type steam turbines. The average number of meters operated during the year was 22,867.

Of the operating account, about \$308,000 was for production, \$122,000 for distribution, \$39,500 commercial and \$43,500 salaries, office expenses and other general expenses. Of the production



BEACH DRIVE; WIDENED LAST YEAR FROM 20 FEET TO 60 FEET.

items, the largest was for fuel—\$155,633, the next largest being for electrical energy purchased, \$107,217, while the amount of current sold to electric corporations was \$57,103. Labor at the steam and electric plant cost \$26,398. The balance of the production cost was for supplies and repairs.

Vibrolithic in Fort Dodge

By C. H. Reynolds*

During the season of 1924, the city of Fort Dodge, Iowa, laid its first Vibrolithic concrete pavement. A contract was awarded to the M. L. Flinn Paving Company, of Sioux City, Iowa, for the construction of some 14,000 square yards on various residence streets with grades ranging from practically level to nine per cent.

This city had previously laid about 45 miles of pavement, mostly sheet asphalt and asphaltic concrete, with some creosoted wood blocks, brick, plain concrete, and bitulithic pavements.

As other municipalities may be considering this type of pavement, a short description of the method of construction might be of interest.

After the subgrade had been prepared in the manner usual for plain concrete pavement, Portland cement concrete composed of 1 part of cement, 2 parts fine aggregate, and $4\frac{1}{2}$ parts of coarse aggregate, all of which, of course, was subject to the approval of the engineer, was deposited to a depth, after striking to the finished crown of the street, of six inches. Immediately after depositing and correcting the surface of the concrete, a coating of surfacing stone, graded through a $2\frac{1}{2}$ -inch screen and retained on a 1-inch screen, was cast by means of shovels upon the surface of the concrete.

This surfacing stone consisted of clean, sound crushed granite with a French coefficient of wear of not less than ten, and was equally distributed in a single course over the surface of the concrete slab. The amount of surfacing stone used was limited to one cubic yard of stone to cover not more than 55 square yards of slab.

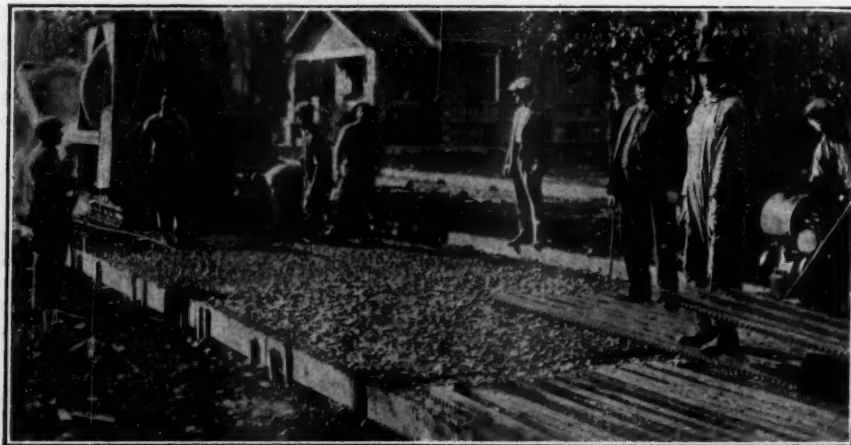
After the surfacing stone had been deposited, flexible wooden platforms approximately fifteen

inches wide and twelve feet long, the under side of which was composed of one-inch cleats spaced one inch apart, were laid longitudinally on the slab from curb to curb, and vibrating machines were rolled over the same, both lengthwise and diagonally, until the bottom surface of the platforms coincided with the finished crown and grade of the street; after which the platforms were advanced approximately one-half of their length and the vibrating continued. This operation firmly imbedded the surface stone into the concrete slab, and so compacted the concrete that workmen could, if necessary, walk immediately upon the slab without sinking into it more than one-fourth to one-half inch. The corrugations in the slab caused by the bottom strips or cleats of the platforms were immediately trowelled smooth by means of long handled trowels worked by the finishers from the curb gutter, after which a belt finish was applied just before the concrete had obtained its initial set. The belt was worked back and forth across the pavement in the same manner as a strikeboard, and this was repeated until a uniform surface of gritty texture was secured. Approved expansion joints one-half inch thick were spaced every forty feet transversely, and over the whole surface of the pavement was spread a solution of silicate of soda, reduced twenty-five per cent by water, while the original moisture was in the mass, so as to prevent the escape of original moisture during the hardening period of the concrete. This coating was spread so as to thoroughly coat the entire surface. All finished pavement was kept free of traffic from two to three weeks after completion.

The construction of this pavement and the results obtained were so satisfactory, that at a second letting of about 15,000 square yards, at which time the price bid for vibrolithic concrete was somewhat higher than for another type of which we have considerable in use in the city, the vibrolithic contractor was able to secure a unanimous waiver, and the second contract was awarded to him at a price approximately four per cent higher than for the older type.

The American Vibrolithic Company, which furnished the vibrating machines under lease to the paving company, also furnished an engineer who was directly in charge of the vibrating operations, and was of great assistance to the engineer in charge of the work in securing a perfect surface to the pavement.

The vibrating machine used in this work is a small one-cylinder gasoline engine mounted on an upright frame on small wheels. It weighs approximately four hundred pounds, and is pushed over the platforms very easily by one



SPREADING SURFACING STONE AND PLACING PLATFORMS
Vibrating machine is seen at extreme right.

*City Engineer, Fort Dodge, Ia.

man. Its speed is variable but is generally run so as to deliver from 1,000 to 1,500 impulses per minute.

The contract price of the first contract was \$2.27 per square yard, and of the second, \$2.10 per yard. Bids for plain concrete at the same letting were approximately the same, there being some variation due to thickness of slab and material specified.

Painting Highway Guard Rails

The Washington State Highway Department, recognizing that the efficiency of a highway guard rail is largely in its warning to the motorist rather than its resistance to the impact

of the automobile, endeavors to keep the guard rails on its highway system as readily visible as possible. The rails are, therefore, painted white. The cost of this is estimated at 11c per running foot. It has been found that the paint becomes dull with the collection of dust and grime, and the problem of keeping them bright has been studied. Repainting would be expensive and, in addition, would not be effective unless the dust be first removed. Cleaning seemed preferable and much cheaper, and hot water and soap used with a brush was found more effective than ammonia and other cleaning preparations. The Department is now having the guard rails thoroughly cleaned at a cost estimated at less than 2c per running foot.

Asphalt Pavement Stability

Results of research looking to improvement in asphalt paving mixtures, and proposed test for stability.

Although asphalt pavements are among the oldest of those now in common use for city streets, the past few years have brought about changes in the general ideas and theories held as to the most effective and scientific procedures in the mixing of materials therefor. One illustration of this is the tendency to adopt the voids in the mineral particles rather than the surface area of such particles as a basis for fixing the amount of bitumen in any given case. An indication that the mixtures adopted as standard for light traffic and heavy traffic are in some respects faulty is furnished by the generally excellent results obtained under heavy traffic in New York City with natural Perth Amboy sand which has a grading much closer to the standard light-traffic sand than to that recommended for heavy traffic. The standards generally employed have developed from our knowledge of the composition and service history of old pavements rather than from an understanding of the reasons for their satisfactory or unsatisfactory behavior. As a result of this, specifications are filled with arbitrary limits which have insured reasonably satisfactory results in the past, but no scientific basis exists for modifying or improving them to meet changing traffic conditions.

In order to supply the necessary information for establishing such a basis, laboratory research has been conducted during the past few months by Prevost Hubbard, chemical engineer for the Asphalt Association, the actual work being done by F. C. Field of that Association. Mr. Hubbard presented at the asphalt paving conference last fall the results up to that time of these investigations. The investigations were continued and in January a paper was presented before the American Roadbuilders Association

by Mr. Hubbard and Mr. Field describing the results of these further tests.

The two principal types of failure to be guarded against in constructing asphalt pavements are cracking and shoving. Under previous traffic conditions the former was perhaps the more troublesome and received most attention, but today shoving or displacement under traffic is undoubtedly the largest problem with which we have to contend. Under old construction conditions the pavements were compacted by relatively light compression and the compaction continued by moderate horse-drawn traffic. At present we construct asphalt pavements one day and the next open them up to a volume and weight of motor traffic which was never even remotely anticipated when the composition of paving mixtures was well advanced in the process of standardization. It is not surprising, therefore, that shoving and rutting are of more common occurrence. There has developed a demand for more thorough initial compression, the use of more mineral filler and less asphalt in the paving mixture, and the use of harder grades of asphalt than were previously thought most suitable. There is, however, no accepted method of determining the limitations of such modifications, nor their inter-relationship, and the same is true regarding the modification of limits of mineral aggregate grading.

"At present we have methods for determining the penetration and numerous other physical and chemical characteristics of asphalt and methods for determining the grading of sand, filler and other mineral aggregates. No matter how intelligently such tests are made and used, however, they do not necessarily insure the most stable mixture, when the various materials are

combined; and yet stability is the primary requisite of an asphalt paving mixture. The very great benefit to be derived from a simple test for stability is, therefore, clearly apparent. If such a test can be made available for use at a paving plant and specifications are so drawn as to admit a wide variety of products, provided that when combined the mixture will have a certain stability value as determined by test, the contractor and engineer will be able to ascertain in advance what particular combination will produce the most satisfactory results. He will also have a wider choice of materials from which to make his selection because our present arbitrary and restrictive requirements can safely be broadened to include many products which are now eliminated by our specifications. It would, therefore, often be possible to obtain not only a better pavement, but a cheaper one as well." The developing of such a test was the main purpose of the investigations described by Mr. Hubbard.

The apparatus used in making the tests consists of a cylindrical steel mold about 5 inches high with an internal diameter of 2 inches. In the bottom of the mold is a circular opening bevelled on the outside and thus producing a shoulder which holds the specimen in place. Following preliminary tests, the diameter of this opening was made $1\frac{3}{4}$ inches for asphalt paving mixtures. The mold is equipped with a snugly fitting plunger for compressing the specimen to be tested and for applying the test load. A bevelled plug which fits into the bottom opening is used during the compression of the specimen, but removed before making the test. About 210 grams of hot, loose paving mixture is placed in the pre-heated mold, the plunger inserted and immediately subjected to a pressure of 4,000 pounds in a compression machine. This gives about 1,275 pounds per square inch, or approximately that obtained under the usual tandem roller. This gives a circular briquette 2 inches in diameter and approximately 2 inches high. The briquette and mold are heated to a uniform temperature of 160 degrees Fahrenheit in an oven and load applied to the plunger in small increments until the asphaltic mixture begins to exude from the bottom opening. This point is quite definitely indicated by a falling off in the

load as the plunger moves downward with the exuding mixture. Different mixtures showed a wide range of stability by this test.

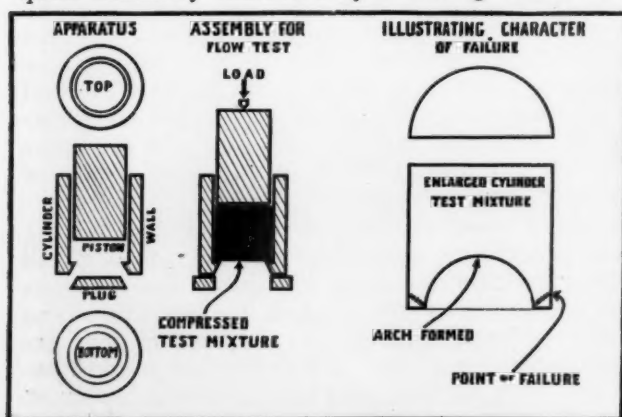
Experience with this test suggested that it might be adapted to investigating the relative mechanical stability of mineral aggregates without reference to the cementing medium. It was necessary to mix some sort of liquid with the sand, and after trying various materials castor oil was selected as the most promising. When standardized procedure was followed, results checked well under 5% variation. For these castor oil mixtures it was found desirable to reduce the diameter of the bottom opening to $1\frac{1}{2}$ inches.

A considerable number of tests were made with these castor oil mixtures and the results of these were the data given most prominence in Mr. Hubbard's paper, especially the effect of adding mineral filler to the sands, which invariably increased their stability. The filler used was commercial limestone dust, two-thirds of which passed the 200-mesh sieve.

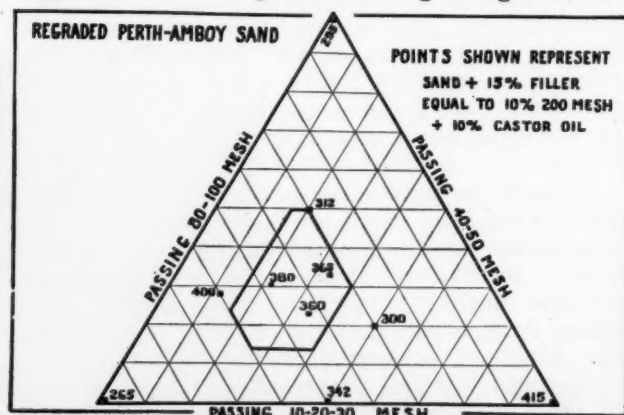
A coarse sand and typical light-traffic sand, both without filler, showed strengths of approximately 95 pounds and 175 pounds, respectively. Filler was then added to each sand and the strength found to increase in proportion to the amount of filler added, but in no case was the strength of the coarse sand equal to that of graded sand for the same amount of filler. For example, light-traffic sand with 10% filler showed a strength of 300 pounds, which strength was not reached with the coarse sand until about 17% of filler had been added.

It was realized that the castor oil furnished a certain amount of surface tension, but an extensive test of this point apparently showed that with 10% or more of oil the results were practically constant for all mixtures and it was, therefore, decided to use 10% of castor oil in all the sand mixtures.

In common asphalt practice two supposedly ideal sand gradings have been set up as standards, one for light traffic and one for heavy traffic. These were tested with various mixtures of filler and, while heavy traffic grading showed higher initial strength, the two gradings showed



APPARATUS USED IN MAKING TESTS.



STABILITY VALUES OF A REGRADED SAND. Area enclosed in heavy line includes all sand gradings admitted under present specifications. The highest value for this sand falls outside this area.

equal strength when each was mixed with 12% of dust, and with an increase of dust the light traffic grading showed greater strength than the heavy traffic grading.

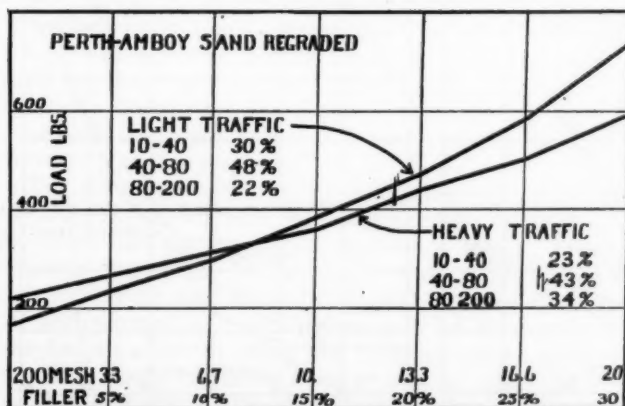
"With the amount of filler used in present-day mixtures it would, therefore, appear that our so-called light-traffic sand is better adapted to heavy traffic than our so-called heavy-traffic sand."

Various sands and sand mixtures were tested and the results plotted, and from these Mr. Hubbard inferred that "It would seem that, while our present specification limits are safe, they are entirely too restrictive." That is, some sands which would not be admitted under the specified gradings would apparently give as good or better results than those meeting such specifications.

No complete series of tests with asphalt as a binder have been made, but from the few that have been made one important deduction appeared to be permissible. There was a marked decrease in stability due to increasing the asphalt from 10.5 to 12.5% where the sand carried 12% limestone dust, an increase of asphalt of 2% over what might be considered as the normal amount cutting the stability value in half.

"It is of course unwise at this stage of our investigation to attempt to develop definite theories or to interpret our test results too literally. It is felt, however, that a method has been devised which, if intelligently used, will enable us to secure a vast amount of information leading to the development of more stable asphalt pavements than we have heretofore secured. The test which has been described gives promise of furnishing valuable data on many questions relating to asphalt paving mixtures which heretofore have been matters of individual opinion or purely arbitrary treatment. Among the most important of these are:

1. The importance of sand grading requirements and the rational limitations of such requirements to adopt.
2. The relative value of different kinds of mineral filler, such as limestone, slate, silica, hydrated lime and portland cement.
3. The proper proportioning of asphalt with different mineral aggregates to secure adequate resistance to displacement.
4. The effect of consistency and other properties of asphalt upon the stability of paving mixtures.



COMPARATIVE STABILITY OF STANDARD LIGHT TRAFFIC AND HEAVY TRAFFIC SANDS

5. The possible adoption of definite stability limits of paving mixtures as determined by test which will undoubtedly allow a much wider use of available local materials and thus tend to reduce the cost of asphalt pavements and at the same time insure greater stability.

"In connection with the last item mentioned, it is believed to be quite feasible to adapt the stability test to general use at asphalt paving plants as well as in regular testing laboratories."

COMPARISON OF MINERAL FILLERS

Limestone dust and Portland cement are at present more extensively used as fillers than any other materials, but slate dust, silica, hydrated lime and other finely divided materials have been used to some extent. Of these, hydrated lime is probably the most widely available and is very finely divided, and although it tends to ball somewhat, the balls are not hard and break down under slight pressure. The cost also is comparatively low. For these reasons it was thought desirable to include this product with limestone dust and Portland cement in a series of tests to determine what, if any, differences might be found between the stability values of mixtures in which these fillers were incorporated separately.

The following table shows the sieve analyses of the three materials as used in the tests. Attention is called to the noticeable difference between them in the percentages passing the 350-mesh sieve. In order to eliminate as many variables as possible, a single sand grading was used in all the tests of this series, the customary light traffic grading being selected.

Sieve Analysis of Fillers

	Limestone dust	Portland cement	Hydrated lime
Retained on 50 mesh.....	1.0	0.3	1.0
Passing 50 mesh, retained on 80 mesh..	2.0	2.7	1.0
" 80 " " " 100 " ..	3.0	3.7	1.5
" 100 " " " 200 " ..	28.0	21.7	3.0
" 200 " " " 250 " ..	8.5	4.6	1.5
" 250 " " " 300 " ..	9.0	3.6	2.0
" 300 " " " 350 " ..	9.0	7.4	3.0
" 350.....	39.5	56.0	87.0
Total	100.0	100.0	100.0

In these tests, as in the previous ones, it was found for all three fillers that the stability values increased as the percentage of filler increased. That of mixtures containing limestone dust was always higher than when the same percentage by weight of Portland cement was used; but the stability of hydrated lime increased so rapidly that with a 12 per cent. mixture the value reached 1300 pounds, five times as great as that of the mixtures containing the same percentage of either Portland cement or limestone. So far as the investigations seem to reveal, the only reason assignable for this is the greater fineness and difference in texture and, perhaps, in shape of the individual particles.

The comparisons given above were on the basis of weight of filler, but it is evident that, owing to the differences in degree of fineness and specific gravity, the volumes which they actually

occupied in the paving mixtures were not the same for equivalent weights. To permit an approximate volume comparison, samples containing the same weight of each kind of filler were subjected to a pressure of 4,000 pounds and their relative volumes measured. Taking limestone dust as unity, the volume of Portland cement was found to be 0.933 and that of hydrated lime 1.933. Making a comparison between the test specimens on the basis of volume equivalents rather than weight, the limestone and Portland cement curves nearly coincide and that for hydrated lime is brought much nearer; in fact, up to 10 per cent. it almost coincides with the limestone and cement curves. The 12 per cent. by weight of hydrated lime reduces to 22 per cent. volume equivalent, at which per cent. the stability value is a little less than three times that of limestone and cement instead of five times, as under the other comparison.

Comparing the results of the tests in another way, it is found that the strength developed by 15 per cent. of limestone dust is obtained by 15½ per cent. of Portland cement and by only 4¼ per cent. of hydrated lime; these being weight comparisons.

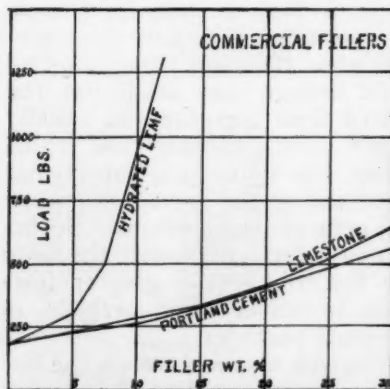
To determine to what extent the finest part of the filler was the most effective, a study was made of gradings of the three fillers which passed through the 350-mesh sieve. The results are much closer than when including the coarser gradings, but the hydrated lime was still higher than any of the others when more than 10 per cent. by weight was used. The increased fineness of the limestone and Portland cement materially increased their stabilizing values when they were added to the extent of more than 10 per cent. On the other hand, hydrated lime showed a lower value than was obtained with the original material, "indicating that in addition to extreme fineness, the grading of a filler also has some effect upon its stabilizing value, even 13 per cent. of material retained on the 300-mesh sieve being effective to a considerable degree."

Reducing these results with the finest materials to a compressed volume basis, the results are brought much closer than in any other comparison—so close, in fact, that, "considering the probable inaccuracies of our method of determin-

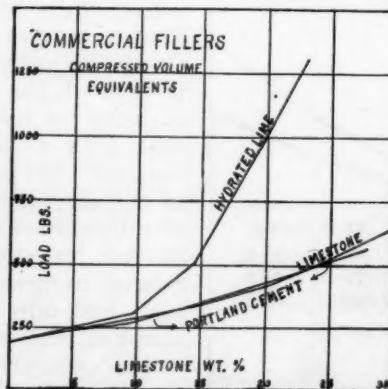
ing volume equivalent, it would seem that but little difference in stability values exists between the extremely fine portion of the three fillers upon a compressed volume equivalent basis."

A comparison of the coarser particles, those passing the 200-mesh and retained on the 350-mesh, was then made, each material being graded and similar proportions of each size used in mixing a composite so as to eliminate the effect of variation in grading. These coarser fillers were found not so effective in increasing stability values as the finer fillers. Here also hydrated lime gave the highest values, which "leads one to think that the shape and surface texture of the individual coarse grains in particular may have some effect upon the value of the filler." The specific gravity of these three coarse fillers was determined, and taking the limestone as unity, the volume equivalent of Portland cement was found to be 0.875 and of hydrated lime 1.167. Reducing the results to a specific gravity volume equivalent basis, the hydrated lime results remain higher than limestone and these higher than Portland cement, although the difference is not nearly so great as when the finest dust was used.

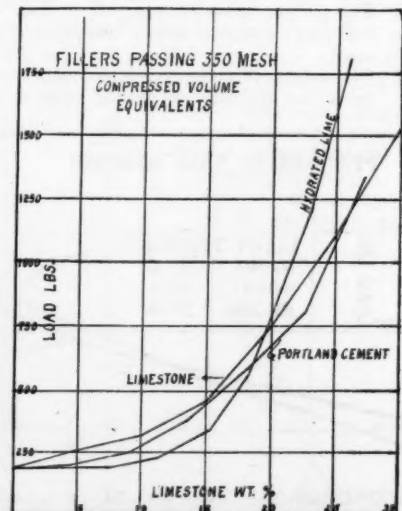
Considering the comparative results obtained with different grades of the same product, limestone dust being used, it was found that relatively coarse limestone proved just as effective as the extremely fine product up to 10 per cent. by weight and that up to 23 per cent. gave higher results than the commercial product. Beyond this the commercial product exceeded the coarse material, but it was suggested as probable that this results to a considerable extent from the fact that the fine material has a higher compressive volume equivalent than the other. Further comparison of tests made it evident that the presence of relatively coarse particles may be desirable and that the grading of the total filler is of some importance. The same conclusions are indicated by comparing results from commercial hydrated lime with those from the grad-



COMPARATIVE STABILITIES OF THE THREE FILLERS: COMPARISON BY WEIGHTS.



COMPARISON OF COMMERCIAL FILLERS ON BASIS OF COMPRESSED VOLUME EQUIVALENTS.



COMPARISON OF FINE GRADES OF FILLERS ON BASIS OF COMPRESSED VOLUME EQUIVALENTS.

ing which passed 350-mesh. "The possibility, therefore, suggests itself that commercial hydrated lime somewhat coarser than the sample used in these tests might prove to be a better filler, both from the standpoint of increasing stability per unit of weight, and also in exhibiting less tendency to ball."

The authors emphasize the fact that they do not consider the results yet arrived at to be in any sense conclusive. "Perhaps the two outstanding indications from the work already done are: 1. That limestone dust appears to be in no way inferior to Portland cement for use as a mineral filler. 2. That upon a compressed volume equivalent basis, hydrated lime appears to be at least equal to limestone dust and Portland cement for use as a filler provided it can be satisfactorily manipulated at the paving plant. These indications will, however, have to be confirmed by subsequent tests on mixtures containing asphalt before they can be accepted as conclusive."

Widening California Highways

For two years or more the California Highway Commission has been widening and thickening some of the concrete roads built before that period, which were being called upon to carry more and heavier traffic. An illustration of this work is the Coast Highway between San Bruno and Beresford. This pavement, originally 24 feet wide, carries traffic from San Francisco reaching 600 or more heavily loaded trucks a day in addition to several thousand of passenger vehicles.

This 24-foot pavement had been constructed of 5-inch concrete base with 1½-inch Topeka top. It was widened to 40 feet by placing a Portland cement concrete shoulder 8 feet wide and 8 inches thick on each side, the thickness increasing to 10 inches in the outer two feet. Heavy, slow-moving trucks are directed to use these shoulders, which were made unusually heavy for this purpose, leaving the central portion free for faster vehicles. This pavement was built 2½ inches higher than the old pavement at the connection, a new wearing surface being placed on the old pavement 2 inches thick at the center increasing to 3 inches at the edges.

As this stretch of pavement was a "bottle-neck," it was necessary to keep it open to traffic at all times. Therefore only one concrete shoulder was built at a time and the new asphalt surface was not placed until the concrete had been thoroughly cured. On Saturday afternoons and Sundays and holidays construction was suspended and all obstructions removed from the roadway.

The concrete was brought in 5-ton trucks which backed onto a sled over the subgrade parallel to the highway, thus getting out of the way of traffic. Two flagmen regulated traffic while the trucks were turning. Five men spread the concrete, two struck off and tamped it, two finished, one set forms and one looked after finishing the subgrade and curing it. This gang made an average run of about 900 lineal feet a day. The concrete was struck off and tamped with a wooden hand template, floated with a transverse wooden float and then a longitudinal

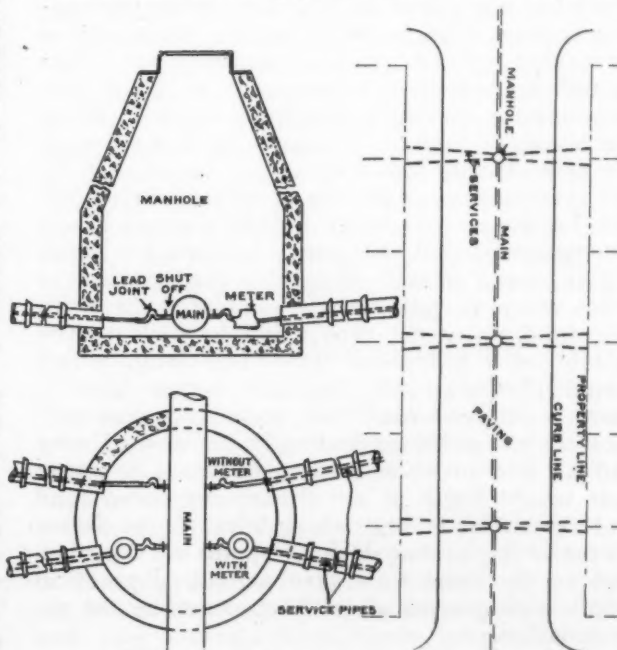
float, and the final finish was given with a wooden belt. While curing, the concrete was covered with burlap kept wet by sprinkling. The burlap used was a long strip wide enough to cover the pavement. This burlap was rolled on a reel revolving on an axle long enough to span the new shoulder concrete, the cart wheels carrying the axle traveling on the old road and the earth beyond the shoulder. When the burlap was to be removed it was rolled up on this reel, and was unrolled from it again when being spread over new pavement.

Outside of the 40 feet of hard surface pavement, an additional shoulder 3 feet wide was constructed of quarry waste and an additional 2 feet wide of earth.

Water Services in Atchison

An unusual method of avoiding cutting into pavements for installing water services is employed by Atchison, Kan., and has been described for us by the city engineer, Earl E. Hellener. The method is employed for water services only, we understand.

A manhole of either brick or concrete is built over the main opposite every alternate dividing line between properties, manholes thus being spaced at intervals of 150 feet where the properties have 75-foot front. The manhole is made perfectly watertight. The bottom is carried somewhat below the bottom of the water main to allow for tapping the main. From each side of the manhole are run two lines of sewer pipe with joints well cemented and laid to a true line and grade, leading to the points along the street line to which it is desired to carry water services. Each line of sewer pipe serves as a conduit in which the service pipe is laid. Four taps are



SERVICE MANHOLE IN ATCHISON

made at convenient places inside the manhole and corporation cocks and goosenecks installed as is customary in trench work. Where desired, meters also are placed in the manhole. The sewer pipe used is of sufficient size to permit the service to be pushed through to the building or removed without binding. It is best to seal the pipe at the property end in order that any water that may leak into the pipe will run to the manhole and not into the basement.

The majority of leaks in the water system are caused by a break in the joint between the main and the service. Should such a leak occur under this system of construction, it would be in the manhole, where repairing is very simple and inexpensive.

In the business district, where it is not possible to dig a trench outside of the pavement to put in or take out the service pipe, it is usually possible to remove and replace the service through the basement. In case there is no basement, a lead service can be used and pushed from the manhole through the tile to the property to be served.

"The initial cost of the above method is somewhat more than the usual way," says Mr. Hellenner, "but the cost of repairs over a length of time will more than offset the difference in first costs, besides the protection to the pavement."

Concrete Road With Inverted Crown

By R. H. Hunter*

Finances often affect the design of a roadway, especially when the designing engineer conscientiously endeavors to obtain the best results possible within the limits of the funds available. Adherence to this principle was the primary reason for an unusual form of construction in Stratford, Connecticut.

For a number of years the town had struggled with the problem of West Broad Street, part of which has a grade of 4.77%. Year after year appropriations were made for placing some sort of permanent surface on this roadway but never enough to complete a pavement of good construction for the entire length of the hill. When the Manager form of government was adopted, the new officials found an appropriation of \$12,000 carried over from the previous administration for use on this street and the Finance Board recommended that the money be used for building as long a stretch of durable roadway as the funds would permit. It was calculated that with this fund the usual type could be built to the middle of a hill about 1,000 feet long, which would discharge all drainage water from a smooth surfaced road onto an unimproved surface which would undoubtedly be washed very badly. The problem was to design a roadway that would begin at an already improved road and extend far enough along West Broad Street to reach the lowest drainage point of the road, and at the same time give a road of practical width with gutters, all without exceeding the appropriation.

*Town Manager, Stratford, Conn.

It was found that an 18 foot road could be built, but to crown and curb a road of this width would be too dangerous for vehicular traffic; if it were crowned and not curbed, the wash of the surface water would continually scour off the shoulders, making it very difficult to maintain them; and the only alternative left seemed to be to make a road with one gutter in the middle and with the shoulders on either side draining toward this concrete pavement. This design was accordingly adopted for the entire length of about 2,600 feet.

The surface of the road is made 3 inches lower in the centre than at the edges and is given the form of a circular arc rather than "V" shape, the principal object of this being to permit a templet to be used in constructing the road with a reciprocatory motion. The roadway is the same thickness at the centre as at the edges.

Catch basins were placed in the centre of the roadway at intervals and connected by 8 in. branches to an 8 in. vitrified tile sewer about 2 feet deep under the middle of the roadway, each catch basin forming a trap for sand and debris. Where cross streets intersect, catch basins are placed just outside the edge of the concrete and in line with the gutters on the cross streets, these receiving the drainage from such streets.

Besides the central drain, there are two other drains along part of the length of the road, one on each side of the concrete pavement, consisting of 3 in. open joint tile. The ditches for these drains were cut with the inner or roadway edge against the concrete and with such depth that the top of the tile is about 6 in. below the edge of the pavement. The ditches were back-filled with coarse gravel well compacted and brought up about midway on the concrete, the top few inches being back-filled with sandy clay. These lateral drains discharge into the catch basins that were placed just outside the pavement.

If it is desired to widen this road at any time, this may be done by extending it on one or both sides with a slope tangent to the existing edges, retaining the present drainage system with the gutter and storm water inlets in the centre of the road.

During the construction of this roadway all kinds of criticisms were made to the town officials of this construction, such as that the road would break in the middle, the edges chip off, gulleys wash along the side of the concrete, and that, when icy, passing automobiles would slide together toward the centre and collide. But none of these things have happened. The shoulders, instead of washing out, have a tendency to fill up so that in the almost 2½ years that the pavement has been used we have not had to place a shovelful of material on the shoulders and no ruts there are apparent. Like any concrete road, this one has checks, the checks running from one expansion joint to the next in some cases. (The expansion joints were placed 30 ft. apart.) The checking, however, has not been excessive considering the very heavy truck traffic that the road has carried.

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CONTENTS

TRENCH CUTS IN PAVEMENTS. Illustrated....	35
Patching a Concrete Road.....	42
BRICK PAVING IN ST. PETERSBURG. Illustrated	43
Pasadena's Municipal Electric Plant.....	45
VIBROLITHIC IN FORT DODGE. Illustrated. By	
C. H. Reynolds.....	46
Painting Highway Guard Rails.....	47
ASPHALT PAVEMENT STABILITY. Illustrated	47
Widening California Highways.....	51
WATER SERVICES IN ATCHISON. Illustrated..	51
Concrete Road with Inverted Crown. By R. H.	
Hunter.....	52
EDITORIAL NOTES	53
Control of City Streets—Dirt Road Investigations	
—Plans of Public Structures.	
One Trench for All Services.....	54
APPLYING COPPER SULPHATE TO RESER-	
VOIRS	55
Ammonia with Chlorine Gas	55
A Judge on Stream Pollution.....	56
Size of Fire Hose.....	56
CLEANING WATERMAINS IN NEW ALBANY..	56
CHARLESTON WATERWORKS NOTES.....	57
Electric Heating in Seattle.....	58
Coal Saving in a Waterworks Plant.....	58
PRECISE LEVELING OF THE UNITED STATES	59
ANOTHER COMBINATION HAUL JOB. Illus-	
trated.	60
Old Brick Pavement in North Carolina.....	61
Richmond's Concrete Catchbasin.....	62
The Engineer and City Building.....	62
RECENT LEGAL DECISIONS.....	63
STREET PAVING IN 1924.....	65
Sheet Asphalt and Asphalt Concrete Laid in 1924,	
Table	65
Rock Asphalt and Bituminous Macadam Laid in	
1924, Table	66
Other Bituminous Pavements Laid in 1924, Table..	67
Stone Block and Brick Pavements Laid in 1924,	
Table	68
Concrete Pavements Laid in 1924, Table.....	69
Waterbound Macadam and Gravel Laid in 1924,	
Table	71
Other Non-Bituminous Pavements Laid in 1924,	
Table	72
Cement Sidewalks Laid in 1924, Table.....	73
Tarring Streets in Berwick.....	72
Engineering in Plumbing.....	74
Finishing Pavement at Street Intersection. Illus-	
trated.	74

Control of City Streets

Millions are spent every year in repairing pavements that have been cut into for the purpose of laying or repairing underground pipes or other public utility structures. And we believe that a large part of this is avoidable.

One of the fundamental causes of this cutting into pavements is lack of centralized control over the city's streets. In many cities the municipal water department is the worst offender. One city engineer in New England writes that every move of the Highway Department looking to reducing the amount of trench cuts in pavements has been blocked by the Water Department.

Such antagonism between municipal departments is, of course, wrong and productive of a criminal waste of the taxpayers' money and reduced serviceability of the pavements. There should be some authority in the government that could and would compel the several departments to cooperate in securing the best and most economical use of the streets as both traffic routes and receptacles for conduits. Where the heads of the departments are appointed by the mayor, he can insist on this as a condition to retaining their positions.

Better still would be a special official, similar to a superintendent of public works, who can with unprejudiced mind study the problem from every point of view. The paving man says a waterworks service should be laid to each curb every fifty feet before a pavement is laid; the waterworks man says this is wasteful of money and will probably waste water also, as many unused services will soon begin to leak. Which is right? What are the relative advantages and disadvantages in a particular case of placing mains and sewers in the sidewalk areas? Neither a water, sewer or paving official can answer this without prejudice, and the decision should not be determined by their relative "pull" with the city council. The tenants and taxpayers are entitled to the most efficient, convenient and economical arrangement and coordination of all public utilities that use the streets, taking into consideration all features of service and cost that affect them.

The problem is one of the most important connected with municipal public works, and is increasing in seriousness and complication as the cost and area of pavement and the numbers of sub-service structures increase. Every city should at once apply to it the best engineering talent it can command and formulate a policy suited to its particular conditions; and then insist on the observance of that policy by all departments as well as public service companies.

Dirt Road Investigations

"Familiarity breeds contempt," and when not contempt, at least heedlessness. That with which we have long been familiar too often is accepted without thought as to whether it can be improved upon.

Concrete pavements are comparatively new and they are receiving an unprecedented amount of investigation and study. Asphalt pavements are much older and have become standardized, and only recently have there been applied to them some of the latest ideas in the principles

of pavement design. Dirt roads have existed since pre-historic animals beat paths through the wildernesses, and modern science has paid them little attention compared to that given other kinds and to their importance.

For they are by far the most important of all roads. Even in this country and day of "good roads" there are ten miles of dirt roads for every one that has been "improved" and the latter are themselves dirt roads—only the wearing surface is improved. If the earth beneath cannot support the traffic, no amount of money will provide a base that will be enduringly effective. If, however, the earth is firm and unyielding in all seasons, a comparatively inexpensive base, or even none at all, will often suffice.

The investigators who will tell us how to secure a good dirt road under any conditions will have solved 90 per cent of the problem of building a good road with any kind of suitable wearing course. No kind of investigation is more valuable to all classes of road users, from the prairie farmer to the city joy rider, than that directed to this end.

Plans of Public Structures

Last spring Frederick W. Albert, who had recently taken charge as engineer of the Knoxville (Tenn.) Water Department, found that there was danger of an early collapse of one of the sedimentation basins, and called the attention of the Director of Public Service to the necessity for immediate action. The discussion of the methods considered available and that ultimately adopted are of considerable interest, but to us the most remarkable paragraph of Mr. Albert's letter was that in which he said:

"This sedimentation basin was constructed in 1914. It is built of reinforced-concrete, at least in part. We have no drawing, specifications or any records in the Water Department files giving us any history or information whatsoever of the plans and specifications under which this basin was constructed."

It seems almost unbelievable that a work of this nature should have been constructed for a city of the size of Knoxville within the last ten years without complete plans and specifications for the same having been filed with the city and carefully preserved in the records of the Water Department. Whether the plans of the purification plant were prepared in the office of the Water Department or by consulting engineers employed especially for this purpose, it would seem as though the officials of the department would have been sufficiently interested and thoughtful for its future requirements to have compiled and filed away a complete set of plans and history of the construction of all of the elements of the plant.

The plans of municipal structures fifty years old or more have no doubt disappeared in many cases, and a number of them were possibly built without preliminary plans. But we hope that there are no other cities of the country which can confess to the lack of complete plans and specifications of any structures, pipe lines and appurtenances, or other

physical features of their water works plants that have been built within the last ten or fifteen, or even twenty-five years. If there are any such, one of their most pressing duties is to immediately ascertain and place on record all the details concerning such plans which it is now possible to obtain, before such records may become unobtainable.

One Trench for All Services

We are informed by P. H. Mosher, until recently superintendent of public works of Melrose, Mass., that that city about a year ago began the practice of laying all house connections—sewer, water and gas—in one trench. As a general thing, the gas service is laid 3 feet below the street surface, the water service a minimum of 5 feet, and the sewer connection from 6 to 8 feet. However, the sewer and water connections are often at the same elevation. In placing these in a single trench, the trench is carried 2 feet wide to a sufficient depth for the sewer connection. Then generally the top 5 feet of the trench is widened a few inches on one side, forming a bench on which is laid the water service; and the top 3 feet is again widened on the opposite side, leaving a narrow bench for the gas service. When for any reason these benches or shoulders are not practicable, the trench is backfilled compactly and the water and gas services laid on the backfilling. Even if the backfilling should settle somewhat, the lead water service and the wrought-iron gas service would not be appreciably affected thereby.

In dividing the cost of this service trench, one-third of the cost of excavation is borne by the water division and two-thirds by the sewer division; while the backfilling of the top 3 feet and the resurfacing are done by the gas company, which bears none of the excavation cost.

The advantage of this plan is stated by Mr. Mosher to be that it requires only one opening in the street, sidewalk and lawn and only one break in the house foundation, and brings all the appurtenances at one point in the basement. The disadvantages are that the connections must all be made while the trench stands open, the sewer being laid first, the water second and the gas third. This is not always convenient, but little real difficulty is encountered in securing the proper sequence of operations. Difficulty is sometimes experienced with the gas connection because the gas company does not have information as to the location and elevation of its mains, but must find the main and start the trench from there.

Incidentally, there is a systematic arrangement of the mains in the streets of Melrose which provides for locating water main and storm sewer on opposite sides of the street, each distant from the property line one-third the width of the street; and the sanitary sewer in the middle of the street. Public service structures are generally located between the storm sewer or water main and the property line. Where feasible, the water mains are placed on the north and west sides of the streets.

Applying Copper Sulphate to Reservoirs

A very thorough discussion of the biology of the water supply of the Island of Jersey in the British Channel was given in a paper before the Institution of Water Engineers in December, 1924 by Wilfred Rushton and P. A. Audin. The authors gave in this paper the results of an investigation made with a view to ascertaining what organisms were likely to cause trouble in the reservoirs and how to deal with them in the most satisfactory manner, and to investigating certain obscure relations between algal and fish life. One point of incidental interest that we note is that the method of collecting samples for microscopic examination was that known as the Sedgwick-Rafter method, developed by these two American engineers and described by the late George C. Whipple in his "Microscopy of Drinking Water."

An interesting feature of the paper was the method employed in applying copper sulphate to the two reservoirs. The authors described this method as follows: "A quantity of the crystals of copper sulphate equal to 0.05 part per million gallons (of the contents of the reservoir) were dissolved in sufficient water to make a solution of 1 pound of sulphate to 5 gallons of water; using an ordinary agricultural spraying machine from a boat, the whole surface of Millbrook reservoir was sprayed, and the dose repeated on three separate days, thus making a total dose of 0.15 part per million gallons, or 0.105 grain per gallon. The boat and spraying machine were then taken to Dannemarche reservoir, which was sprayed on four separate days, each spraying being equivalent as above to 0.05 part per million. It was thought advisable to repeat the treatment of Millbrook reservoir a few days later, so that this reservoir had ultimately a total dose of 0.3 part per million gallons. The result of this treatment was entirely satisfactory."

Successive determinations of the green algae in the reservoirs indicated that the first dose would have been sufficient and the second dose was unnecessary. The sulphate was applied between June 30th and July 13th and the total green algae in one reservoir were reduced from 5108 per c.c. on July 6th to 312 on July 20th and to 14 on August 8th; while in the other reservoir the numbers were 3752, 356 and 92 on the same three days, respectively.

The authors consider that this method of applying the sulphate, as compared with the ordinary one of dragging bags of sulphate crystals through the water behind a boat, offers the following advantages:

"1. The salt is evenly distributed over the surface instead of in streaks, in which for a time the strength is sufficient to be injurious to fish life.

"2. The diffusion of the salt is entirely vertical, whereas with the bag method the diffusion between two passages of the bag is, so far as the surface layers are concerned, horizontal and a slow, uncertain process in still waters.

"3. By dividing the dose, there is a greater certainty of the whole surface being treated and, more-

over, if microscope examination is carried out concurrently, the treatment can be stopped as soon as the desired effect is obtained."

With reference to the spraying of copper sulphate on the reservoir, another member of the Institute, in commenting on the paper, suggested that in deep reservoirs it would be better to spread the required dose over a longer period than in shallower ponds, so that the natural vertical circulation might assist in the process. The cost of treating the reservoir by the spraying method was said to have been less than 10 shillings, or about \$2.25, per acre.

The authors also studied the relation between the temperature of the water and increase of algae, and believed that the facts learned gave them reason for saying that "in the spring and summer, as regards green algae and the protozoa, any rapid rise in temperature of the water in the reservoirs should be looked upon as a probable danger signal. Although a close comparison will reveal instances which appear to be in contradiction to this conclusion, it will be found that in the great majority of cases any increase of these organisms has been preceded within the previous three weeks by a fairly sharp rise in the temperature of the water. The connection between temperature and organisms is perhaps more directly traceable in respect of the protozoa than of the chlorophyceae. If in the spring or summer there is any sudden or considerable rise in temperature of the water, and if simultaneously or within the following fortnight there is any marked increase in the number of chlorophyceae or protozoa present, it is advisable to apply the copper sulphate treatment. It must be remembered that organisms multiply at a phenomenal rate and that in a very short space of time cure may be necessary instead of prevention, which should be aimed at and is so easily obtained." One outstanding advantage of prevention is that it is not followed by the unpleasant taste frequently given to the water by the killing of algae and the liberating of their globules of essential oil.

Ammonia with Chlorine Gas

Experimental work has been carried out at the Army School of Hygiene by Major C. H. H. Harold and Captain A. R. Ward, English officers, to demonstrate that chlorine gas in association with ammonia gas is a more efficient sterilizer of water than chlorine gas used alone. Nineteen experiments were carried on and a report thereon published last year in the journal of the Royal Army Medical Corps.

The organisms used in the experiments were the germs of cholera, typhoid, dysentery, *B. enteritidis* and *B. suiptifer*. The authors concluded that the anomalous results met with in practice can be attributed to inhibition and that sterilization by chlorine and hypochlorite of waters with high colloidal content is unreliable if reliance is placed upon examination for the presence of free chlorine alone; that where ammonia is added, only one-third as much chlorine gas is required to secure sterilization in a concentration of 1:10,000 pollution as is necessary if bleaching powder is used; that the addition of ammonia to the extent of one-third part per mil-

lion increases the sterilizing power of the gas but may even decrease that of bleaching powder; and finally that the addition of a quarter to a half part of ammonia per million of water prior to its exposure to chlorine gas increases the sterilizing effect.

A Judge on Stream Pollution

Sanitarians are not the only ones who look with disfavor on stream pollution, as is testified to by the following opinion handed down by Judge Flickinger, Justice of the Peace in and for Green County Township, Sandusky County, Ohio:

The Attorney General of Ohio having rendered a special opinion that magistrates have final jurisdiction in cases such as this, it is my intention to decide this case on as broad lines as possible.

The charge against the defendant, F. E. Stahl, is a simple one. Mr. Stahl runs what is commonly known as a cut-rate drug store at Fremont, Ohio, and he is charged by A. C. Snow, an inspector of the Ohio Board of Pharmacy, with selling him an ounce or two of callicylic acid, contrary to law. The state of Ohio brought a good deal of its official machinery to bear in this matter.

Briefly, let us examine some of the things the state of Ohio does and does not do in Sandusky county to punish offenders. There is an institution at Fremont, known as the Sugar Beet Factory, which has been in operation for many years. The poisonous refuse from this factory is turned into the Sandusky river year after year, when the factory is operated. Two years ago I read in one of the Fremont papers that "tons and tons" of fish were thus destroyed.

A few weeks ago, standing at the Clyde depot was the Fish and Game Commission's car, named "Buck-eye." The papers announced with considerable flourish that this car had distributed many thousands of young fish in the streams in this part of the state, among others in the Sandusky River.

At the present time the inky pollution coming from the beet factory can be seen for miles and miles down the Sandusky River. In comparison with the outrageous pollution of one of Ohio's great and beautiful rivers, the offense of Mr. Stahl seems infinitesimal.

I find Mr. Stahl guilty of the offense with which he is charged, and under the law must fine him fifty dollars and costs, but the fine is suspended until the state of Ohio takes steps to stop the pollution of Sandusky River. I will remit my own costs, but expect the defendant to pay the costs of the witnesses and the constable.

Size of Fire Hose

In a paper before the fall convention of the New England Waterworks Association, W. R. Conard made several recommendations concerning the size of fire hose and hydrant spacings, the former of which at least differed from ordinary practice.

It is his judgment that, except in localities having tall buildings covering considerable ground areas, there should be a distribution system so constructed as to supply an ample quantity of water for a sufficient number of hose streams to handle the ordinary fire, at a pressure of 90 pounds at the hydrant, with the hydrants spaced not over 200 feet apart. Such a pressure, without being excessive for plumbing, would give sufficient water to the short lines of hose which this hydrant spacing would permit to take care of a fire on the upper floors of a six-story building or less and at the

same time enable the firemen to work at a safe and comfortable distance from the burning building. Pressure boosting apparatus (pumpers) should be kept on hand for fires in taller buildings, or reaching serious proportions, but would not be needed for the majority of fires.

Two and one-half inch hose is generally looked upon as standard, but Mr. Conard outlined some possibilities of 3-inch hose and 1½-inch hose. With 90-pound pressure it would be possible to get, through 300 feet of 3-inch hose, 335 gallons of water as against 235 gallons through 2½-inch hose. Three-inch hose is a little heavier but can be easily handled. If two 1½-inch hose lines each 250 feet long be siamesed on the end of the 3-inch hose, where the pressure would be 50 pounds, these two lengths of hose extending 500 feet from the hydrant would deliver within 15 gallons of as much water as a line of 2½-inch hose 500 feet long, which water could be applied to the fire from two points instead of one. If a heavier stream were needed, the siamese coupling could be removed and a line of 2½-inch hose be substituted and we would then have 75 gallons more water than if the entire line from the hydrant were 2½-inch.

In brief, he suggests spacing the hydrants a maximum of 200 feet, then arranging the hose-carrying apparatus of the fire department to carry 300 feet of 3-inch hose, 400 feet of 1½-inch hose and 500 feet of 2½-inch hose, together with nozzles for 3-inch, 2½-inch and 1½-inch hose, and the necessary adaptors and siamese connection.

Cleaning Water Mains in New Albany

The waterworks system of New Albany, Ind., was first installed in 1875, and in 1923 most of the original distribution system was still in service. The water, taken from the Ohio river, frequently contained sediment, and this, with incrustation, had greatly decreased the capacity of these pipes during the 48 years of service.

Work on cleaning the mains was begun on a large scale in 1922, but only in the smaller mains in the outlying districts. The results obtained here were so satisfactory that it was decided in 1923 to undertake what seemed like a very hazardous job—the cleaning of the supply mains from the reservoirs to the city. These mains were a part of the original plant and of course their capacity was greatly reduced, and this affected the entire system. One of them, 16 inches in diameter, supplied the manufacturing part of the city and taking it out of service would reduce the volume of water that could be supplied by approximately 60%. There were two other lines, each 12-inch. It was decided to clean the two smaller lines first in order to increase the amount available when the 16-inch line was out of service for cleaning.

Charleston Waterworks Notes

The two 12-inch lines pass under two creeks and through a tunnel about 300 feet long. Fortunately the cleaner passed through these critical sections of the line without stopping; but it encountered an obstruction at the first street in the city where, on breaking out the pipe, it was found that stoppage was due to a joint so poorly yarned that 100 pounds of lead had been used in running it, a large part of which had entered the pipe. After this, the cleaning was quickly completed as no more serious trouble was encountered. The first section cleaned in one shot was 2,200 feet, the second was 2,700 feet and the third was 465 feet, which completed the 12-inch lines.

Owing to the importance of the 16-inch line, the city hoped to begin cleaning it the first thing in the morning and have the line back in service by noon. Every manufacturing concern affected was notified beforehand and requested to take particular care concerning fire, and the fire department also was notified and requested to use chemicals and spare water wherever possible if a fire should occur while the pipe was out of service. All valves leading to and from the 16-inch line were inspected beforehand and found to be in good condition.

After inserting the cleaner at the outlet from the reservoir, the first trouble encountered was the breaking of a stem of one of the valves in the 16-inch main at the foot of the hill. A half day was consumed in remedying this. The cleaner was again inserted in the afternoon and traveled the entire distance of two miles in about forty minutes without any trouble. The amount of material removed from the pipe was remarkable. In addition to that washed into the sewer, two 5-ton truck-loads of reddish brown substance resembling iron oxide was washed out onto the street. All replacements were immediately made, and at 5 o'clock that evening the valves on the line were opened.

Flow tests were made within the next few days, and it was found that the delivery had increased from 30 to 45%.

In addition to this, the Department cleaned $\frac{1}{2}$ -mile of 10-inch and several miles of 6-inch and 8-inch main with equally good results. In consequence of this increased capacity, it has been possible to postpone indefinitely the great expenditure for new distribution lines which would have been necessary.

As a result of this experience, another contract was signed with the watermain cleaning company for cleaning six to eight additional miles of main. The city uses its own organization for the work except for a superintendent, who is furnished by the company, which also furnishes the equipment. The average cost to the city, including all sizes, has been approximately 22c. a foot.

An incidental advantage connected with the cleaning is that it leads to the detection of leakage in mains, valves that are defective or wholly or partially closed, and information concerning location and sizes of old mains, concerning which no data were to be found in the records.

In spite of difficulty in obtaining labor and high wages, the annual report of the Water Department of Charleston, S. C., for the year 1923, makes a satisfactory showing financially. It also contains a number of interesting features relative to the physical operation. In his report as manager and engineer, J. E. Gibson states that the disbursement for operation and maintenance of the distribution system was \$2,934 greater than the previous year, almost the whole of this being due to repairs of service pipes. These repairs were made in conformity with the policy of renewing all old service pipes in the streets and under sidewalks to the property line with AA lead pipe. In addition, \$14,113 was spent on inspection, repair and renewal of all mains, valves and service pipes in advance of new paving. After paying all regular operating and extraordinary expenses, repairs, maintenance, depreciation, sinking fund and interest on bonds, but exclusive of taxes, the net income was \$121,485. This surplus was turned back into the plant in the form of extensions and improvements, thus avoiding the necessity of a bond issue. During the six years and three months that the Commission has been operating the plant there has been a total net earning of \$768,585, all of which has been expended in improvements and extensions.

Unaccounted for water is being reduced as much as possible. The amount actually accounted for by small meters as compared to the total pumped into the mains, as measured by the station meter, varied from a minimum of 73 per cent in May to a maximum of 84.3 per cent in December, averaging 81.2 per cent for the year. The Commission states that it will not be content until it has accounted for at least 85 per cent of the water pumped to the city.

The water is treated with liquid chlorine and sulphate of alumina as a coagulant, followed by sedimentation and filtration through rapid sand filters. The alkalinity is restored by use of sodium hydroxide, the use of which was begun in the fall of 1922 and continued throughout the year 1923. Concerning this practice, Mr. Gibson reports: "The advantages obtained in this treatment are that the water is artificially softened rather than hardened as with the lime treatment, and the carbonic acid content is more easily controlled."

"We find that the caustic soda method of treatment is very much simpler, more constant in its action and cleaner than the lime method and, while we estimated the cost to be considerably greater than lime, we find that, due to the reduction in pumpage and other economies effected, the gross cost has been immaterial, especially so when the quality and constancy of the product obtained are considered. Further, there

is undoubtedly a material saving effected in the amount of soap and softening compounds required. The manager of one of our laundry companies stated to us that he had been enabled, due to the change in the treatment of the water, to entirely dispense with all softening compounds."

All fire hydrants were inspected, repaired, painted and numbered during the year. The color adopted in painting them was an orange yellow, with black near the pavement line to take the splash from the ground. This color has proved very distinctive by both sun and artificial light.

AERATION OF WATER

There was found to be an absence of dissolved oxygen in the raw water and also in the filtered water supply, which caused numerous complaints from the consumers. Effort was made to meet this deficiency by pumping air into the raw water suction wells, the effluent from the filters and the clear water reservoir. The results were only partially successful and very expensive. In an effort to provide a more effective aerating process, an aerator was installed on the discharge line leading from the filters to the clear water basin. This aerator was made by bringing the end of the 30-inch effluent pipe upward to the surface of the clear water basin and continuing it 18 inches above the surface. An umbrella-shaped platform approximately 12½ feet in diameter was constructed on this outlet, and on the upper surface of it strips of wood or riffles were fastened and below each riffle a line of holes were bored through the decking. All the water that entered the clear water basin flowed up through this 30-inch pipe and overflowed across the umbrella platform with a final free fall of 15 inches into the basin. In passing over the riffles the water created a vacuum, sucking air up through the small holes bored in the deck. Mr. Gibson states that the result of this was an aeration giving approximately 60% saturation to the filtered water under the most adverse condition when the raw water contained no dissolved oxygen. All other methods of aeration were discontinued and the result of this one was so gratifying that it has been made a permanent feature of the operation. It involves practically no cost other than the first cost of construction.

Electric Heating in Seattle

In the annual report for 1923 of the Seattle Department of Lighting, some figures are given concerning use of electricity for heating residences, based on a charge of 1 cent per kw. h., which is the residence charge for all over 240 kw. h. per month, the highest rate being 5½ cents for the first 40 kw. h.

The department made a number of tests on the efficiency of residence coal furnaces and concluded this was about 40 per cent. On that basis they figure that heating by current at 1 cent is equivalent to using coal at \$20 a ton, or even \$15 for small residences, which is about the cost of soft coal in Seattle. It is estimated that the

cost of heating an average 5-room house in Seattle with electricity would be \$175 a year.

The report gives as the advantages of electric heating: cleanliness; convenience; ability to heat some rooms and not others at will; supplementing a coal furnace for additional heat in some rooms or at certain hours, or when not cold enough to start the furnace. The approximate yearly consumption is 2½ kw. h. per cubic foot of space heated. The rate of use of current in Seattle averages 15 per cent of the year's consumption in January, grading down to less than 1½ per cent in August. While the summers are cool there, the winters are warm, grass staying green the year around.

Coal Saving in a Water Works Plant

A paper with the above title was read before the Indiana Sanitary and Water Supply Association by W. L. Younce, superintendent of water of Newcastle, Ind. Mr. Younce first discussed the subject generally, calling attention to the points in connection with plant operation that needed special attention, and supplemented this with a statement of the results that he had obtained at Newcastle.

When he became superintendent he found both pumping plant, well plant and distribution system in poor condition. In addition to the water service, the city also furnished street lighting. The coal consumption was about 20 tons per day and the pumpage was about 2,000,000 gallons per day for a town of less than 12,000 people. Three-inch boiler tubes were found to be so full of lime that it was difficult to get a ¾-inch pipe through them, and the boiler shell and water legs had a heavy coating of scale.

By use of a boiler compound, the scale was softened so that it could be removed and the tubes were turbed. Leaks in the furnaces were stopped and a reduction in the fuel bills was soon noticed. New pistons and rings were fitted in the engine used for the lighting plant, the throttle valve ground, new admission and exhaust valve put in, and the steam consumption of this engine was thus reduced approximately one-half.

Water waste then received attention. Three days were consumed in inspecting fifty sewer flush tanks. It was found that some of these were flushing every 15 minutes instead of once or twice a day. Premises were inspected for leaking appliances, and leaks in service mains were located and remedied. (Incidentally, the services were laid in the same trench as the sewer branches and escaping water was running directly to the sewer. Mr. Younce believes that water and sewer services should never be laid in the same trench). Leaks in steam lines were stopped, valves reset and cylinders rebored where necessary.

The result of this was that the water pumpage was cut down from about 2,000,000 gallons per day to about 1,000,000, and the coal consumption from 20 tons to about 8 to 10 tons. In spite

of the addition of 1500 consumers in the nine years since then, including several factories, the pumpage is not as great as it was before the improvements, while the income is three times as great.

The special points to which Mr. Younce directed attention as a means of preventing waste of coal were as follows:

The fireman—he will often burn two or three times his wages in wasted coal.

The furnace—poor designs, air leaks in walls, filling up of combustion chambers and excessive draft are sources of waste.

The boilers, if allowed to get foul inside or out.

Leaks in the steam pipe system—valves, valve stems, flanges, etc., and lack of good insulation.

Feed water heater—heating feed water saves coal both directly, and also indirectly by removing, in the feed water heater, a considerable amount of scale-forming substances that would clog the boiler.

Blowoff valves—valves and piston rings in pumps and compressors. Leaks in these waste the coal used for producing the steam lost.

Lubricants for the machinery—a high grade of oil will pay for its higher cost in the smaller amount used as well as in less fuel required to overcome friction.

Precise Leveling of the United States *

Methods employed by Coast and Geodetic Survey, which has run thirty-two thousand miles of such levels

Early in the history of the United States Coast and Geodetic Survey it was found expedient to connect the coastal surveys on the east and west coasts in order to reduce all surveys in this country to a common datum. Accordingly the transcontinental arc of precise triangulation was established. To strengthen the connection and extend the area covered, other arcs also were surveyed. In connection with this, lines of accurate levels were run and the elevations so obtained were useful to topographers using the triangulation points and to other surveyors. The value of these levels soon became so evident that a careful study was made of levelling work in order that long distances might be covered without large accumulations of error.

Over 48,000 miles of precise levelling have now been run in the United States, 32,000 miles by the Coast and Geodetic Survey and the remainder by the United States Geological Survey, United States Army and other federal bureaus and commissions and by three of the larger railroad systems. This network of precise levels enters all

the states but one and forms over 100 closed circuits. It is desired ultimately to have the net so cover the country that every point will be within 50 miles of a standard bench mark.

These standard benches frequently will eliminate the necessity of running long lines of levels by engineers in connection with private or public enterprises; but its greatest value lies in its function of joining together all surveys throughout the country made from these benches and basing them upon a common datum.

As the cross connections of the net became more extended, more or less important adjustments of previous elevations were found to be necessary. There have been four general adjustments, the last having been made in 1912, at which time the net had become so extended and the levelling of such accuracy that all the elevations throughout the entire network may now be considered as standard for all time.

These bench marks are referred to mean sea level, which is assumed to be the same on the open coasts of the Atlantic Ocean, Gulf of Mexico and Pacific Ocean. This assumption may not be strictly correct as there seems to be an unexplained difference, the mean sea level being somewhat higher in the north than in the south. However, these differences are so small that the accuracy even of modern precise levelling is not sufficient to make their existence certain.

In carrying out this system of precise levelling, orthometric corrections are made to eliminate from the observed results the effect of the convergence of level surfaces as the poles of the earth are approached, the earth being an oblate spheroid. As an illustration of this correction, in the long and high north and south line between San Diego and Seattle the total correction amounts to 4.07 feet. The accuracy required in performing precise levelling admits of corrections to close circuits not exceeding three-quarters of an inch per hundred miles.

Precise levelling usually follows railroad lines where they are available, since they give the shortest distances and are free from steep grades. The levelling is performed in sections usually about one kilometer in length, this section being run forward and back until the values differ by not more than 4.0 m.m. \sqrt{K} , where K is the length of the section in kilometers. It is required that the forward and backward runnings of a section be made on different days, and if possible at different times of the day, and also with as widely different atmospheric conditions as possible. Two rods are used and the foresight is taken first at one station, the back sight first at the next, this eliminating any error due to the settling of the instrument after setting it up. Each rod is read twice on any turning point, first as a foresight, then as a back sight from the next station ahead, thus eliminating errors due to any difference in the lengths of the rods.

The heads of rail spikes are commonly used as turning points, clean, firm spikes being selected. It has been found that even if a train runs over the track while a spike is being used

*Abstract of paper before Boston Society of Civil Engineers by Elliott B. Roberts, Junior Hydrographic and Geodetic Engineer, U. S. Coast and Geodetic Survey.

as a turning point, a firm spike inevitably returns to its turning point within the accuracy of reading the rod.

While it requires several weeks for a new observer to become proficient in the use of the precise level, an experienced observer can cover $2\frac{1}{2}$ miles per hour under ideal conditions. The most advantageous weather is that heavily overcast and cool, when the absence of heat waves in the air permits a length of sight of 150 meters, the longest allowed. Under average summer conditions 80 to 100 miles a month of double run line can be completed. Where the railroad traffic is light, motor speeders are frequently used, sometimes with the instrument mounted permanently on a car; and under such conditions as much as 170 miles a month has been done by a single party.

Another Combination Haul Job

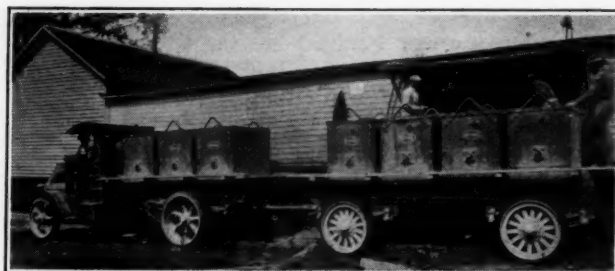
Fifteen miles of concrete pavement laid from three proportioning yards, haul being by combined truck and industrial railway

In the January issue of *Public Works* we described the combined haul method employed by the Mellert & Weidener Co. in constructing about two and a half miles of concrete road in Ohio. Another firm that employed this method last year in Ohio, but with several variations in detail and for a much larger job, was Hill & Hill, of Elyria, Ohio.

The road referred to was the Niles-Ashtabula road, of which there was about 15 miles in this contract. It was a concrete road 16 feet wide, and 7 inches thick, increasing to 9 inches at each edge and averaging $7\frac{1}{4}$ inches. The mix was proportioned 1:1½:3.

A railroad ran approximately parallel to the road under contract, but about four miles distant, and connected with it by several highways.

The soil in that section is clay and almost im-



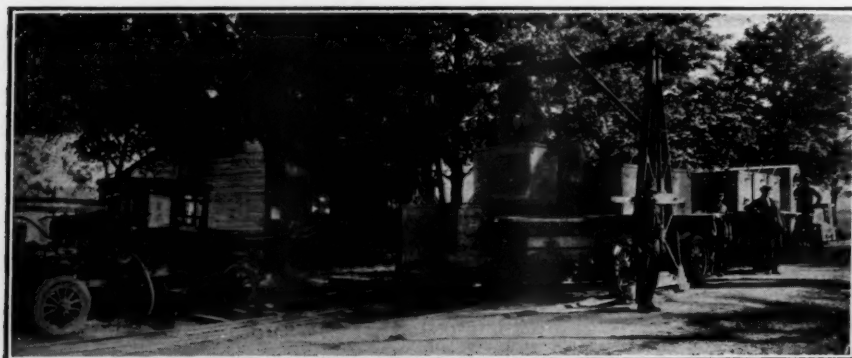
TRUCK AND TRAILER CARRYING SEVEN BATCH BOXES

Placing cement in boxes at cement shed.

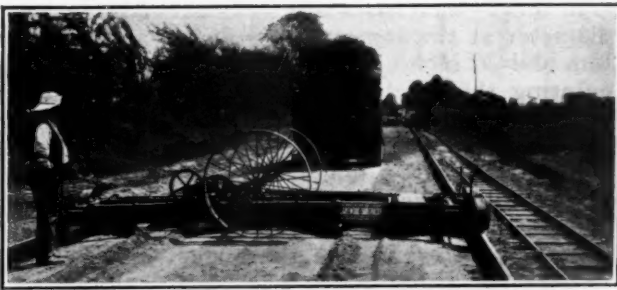
passable for heavy trucks when wet. About three miles of the road was old macadam in very bad condition, the other twelve miles was natural clay with some gravel mixed into it. Hauling the concrete materials over this road before the frost had dried out and for several days after each rain would, the contractor decided, be impracticable, and hauling on the subgrade even more so.

Under these conditions the contractor planned to lay a narrow-gauge track along the side of the road, over which the concrete material would be carried to the mixer in batch boxes; these boxes being brought to this track from the railroad by trucks and trailers, the transfer from truck to car being made by a transfer equipment. Instead of transferring at only one point and laying narrow-gauge track from there to each end of the job, three sites for proportioning yards, with bins and mixers, were chosen along the railroad, each on a road leading directly to the job. Two miles of industrial track was used, with the transfer station at one end, and by the time this length of road had been completed, that at the starting end was sufficiently set to allow trucks to use it, and each day thereafter about 600 feet of track (that being the length laid in a day) was taken up at the rear end and relaid ahead, the transfer station also being moved ahead the same distance. When the concrete had been laid for $2\frac{1}{2}$ to 4 miles from the first location of the transfer station, the bins, mixer, etc., were moved to the next site selected for a proportioning yard, the transfer equipment moved to the point where the road from that site crossed the job, and the track laid back from there to the point where the concrete had stopped—about 2 miles in each case.

The first proportioning yard was set up at East Orwell, which was $4\frac{1}{2}$ miles by road from the job. From here the road was laid for 2 miles south and $3\frac{1}{2}$ miles north. Then the proportioning yard was moved to Rome, $3\frac{1}{2}$ miles from the job, from which were built 2 miles south and 4 miles north. The yard was then moved to Jefferson, $2\frac{1}{2}$



TRANSFER EQUIPMENT USED BY HILL & HILL
Air compressor mounted on Ford truck at extreme left



SHAPING AND ROLLING SUBGRADE
Narrow-gauge track at the right. Concrete mixer in background.

miles from the job, from which the remaining $3\frac{1}{2}$ miles was constructed.

At the proportioning yard the stone and sand were stored in overhead bins of about 100 tons capacity, kept filled by a gasoline crane. From these the batch boxes, three on a 5-ton truck and four on its 8-ton trailer, were loaded, each with a 6-bag batch, the cement being added either directly from the cars or from the cement shed. It took an average of $7\frac{1}{2}$ minutes to load the 7 batch boxes.

The transfer equipment, designed by the contractor, consisted of an Ingersoll-Rand type D 2-ton air hoist, mounted on an 8-inch steel I beam, which was supported by two A frames, one on each side of the road. An air compressor mounted on a Ford truck supplied the air for the operation. In moving this transfer equipment, which required about an hour and a half, it was raised and carried by two 6x6 timbers placed on top of the batch boxes on one of the trucks.

Transfer from car to mixer skip was by means of a small derrick mounted on the mixer, the weight of the descending skip furnishing the necessary power.

At the proportioning yard, four men, the crane operator and foreman, handled the stone and sand. Placing the cement in the batch boxes was contracted to one man who, with four helpers, took care of this at so much per sack.

The truck hauling was contracted to a trucking contractor at so much a batch-box mile. He used six trucks and six trailers, which easily kept the mixer supplied with 25 to 40 batches an hour. The average haul was 4.35 miles. It reached a maximum of 6 miles, when another truck and trailer were really needed, but they were not added as this maximum lasted for only a short time. On this 6-mile haul the outfits made seven round trips in ten hours. Allowing $7\frac{1}{2}$ minutes for loading and the same for transferring batch boxes, the trucks averaged ten miles per hour.

At the transfer point four men and a foreman were used.

The industrial railroad equipment consisted of two locomotives and three trains of 7 to 9 cars each. The locomotives were left attached to the train at the mixer, shifting cars there. At the transfer point the locomotive switched to the extra train. Two miles of track was used. The

average haul was $1\frac{1}{2}$ miles. By liberal use of sand a locomotive could haul a 9-car train up 5 per cent. and 5.9 per cent. grades. This outfit easily kept the mixer supplied. Taking up and relaying 600 feet of track a day was performed by six men and a foreman, who also maintained the track.

At the mixer three men were used to shift the boxes from cars to skip and back to cars.

The contractor started work on April 23rd and finished it 184 days later. Of this period, 26 days were Sundays and Fourth of July, 15 days were lost on account of rain, 7 days moving the proportioning yard, and 1 day on account of no material; leaving 135 days on which concreting was done. The average for these days was 586 lineal feet, or 21.1 cu. yds. per hour. The maximum was 878 feet in 10 hours, or $31\frac{1}{2}$ cu. yds. per hour.

On July first the contractor was 9,000 feet behind his schedule but finished a week ahead of it. It is his opinion that he could not have worked more than 50 per cent. of the time, instead of 73 per cent., if he had relied on truck hauling alone.

Old Brick Pavement in North Carolina

By Harry Tucker*

A number of brick pavements more than thirty years old are to be found in cities of Ohio and neighboring states. Bucyrus, Ohio, claims one thirty-three years old; Lincoln, Nebraska, one thirty-four years old, and Springfield, Illinois, one thirty-five years old.

However, brick pavements as old as this along the Atlantic seaboard are believed to be rather uncommon and therefore information concerning one in North Carolina is of interest.

In carrying out an extensive paving program, the city authorities of Raleigh, N. C., recently took up a section of brick pavement on Hargett street between Fayetteville street and Salisbury street, in the downtown section of the city. The writer had observed this pavement and the heavy traffic of all varieties that it carried for a period of fourteen years and had been impressed with its wearing qualities. Endeavoring to learn the history of the pavement, he found one of the men who had assisted in laying the brick, who informed him that after consolidating the earth base a sand cushion about 2 inches thick was spread and the brick laid with close joints perpendicular to the street line. After laying, sand was scattered to cover the brick and thoroughly swept into the joints and two men with wooden tampers tamped the brick into place. As nearly as this man could recall, the pavement was laid about thirty years ago. He has lived in Raleigh ever since and does not know of any maintenance at all having been done on this pavement; while the writer is sure that nothing has been done during the past fourteen years. When taken up recently,

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it was apparently in as good condition as when first constructed.

Some of the brick used in this pavement had lugs on the sides while others were smooth. They were branded "Reynold's Block." Bricks showed little evidence of wear except that a few edges were rounded and chipped off. A test in a standard rattler showed a loss of 14.34%. Blanchard in the "American Highway Engineers' Handbook" gives the general average loss for modern pavement brick as 22%. This brick would, therefore, appear to be of exceptionally good quality.

It is said that this short section of brick pavement was constructed as an experiment to determine whether more of the same kind should be laid in the city, but for some reason no more had been laid although this experimental stretch certainly would seem to have been a success.

Richmond's Concrete Catchbasin

The city of Richmond, Ind., constructs its catchbasins of concrete and on a plan different from that ordinarily employed. The excavation for the basin is made circular, 3 feet in diameter and from 7 to 8 feet deep, the earth being cut true to act as the outer form of the concrete lining. Both walls and bottom of the basin are made 6 inches thick of 1 cement: 6 gravel. After the excavation has been completed the concrete for the bottom is placed and trowelled. A collapsible steel form is assembled on the street and lowered into a hole, this being made of 10-gauge steel in two complete cylinders each 4 feet long. Each section is composed of two or more segments of a circle, there being a 2-inch metal strip fastened at the joint between segments containing latches which fasten on the abutting sheets and hold them together. Each sheet of segment is reinforced at the top, bottom and center by a 1¼-inch angle iron on the inside. These two forms are set one on top of the other and adjusted to position, and the concrete poured outside of them. The concrete is placed in small quantities and well spaded to secure a smooth inner surface. Each basin requires about 1½ cubic yards of gravel and six sacks of cement. The inlet and outlet pipes are placed in position before concreting. While the concrete is still soft the iron manhole head is imbedded in it at the proper grade.

The forms are removed the following day by simply turning the latches on the side strips, when the segments can be removed one at a time, being loosened from the concrete by tapping them with a hammer. The average cost is stated by D. B. Davis, city engineer, to be as follows:

1½ cubic yards of gravel at \$1.35.....	\$ 2.02
1½ barrels of cement at \$2.80.....	4.20
20 hours of labor at 45 cents.....	9.00
2 12-inch elbows for water seal.....	5.00
Ring Cover 250 lbs. at 4 cents..	10.00
Total	\$30.22

In this 24-inch basin is set a bucket 23½ inches diameter at the top and 21½ inches at the bottom and 36 inches high, which receives the dirt entering the catchbasin, which dirt is removed by lifting the bucket from the catchbasin. The bucket is made of 10-gauge Armco ingot iron. The bucket has a hinged bottom which opens downward. The catchbasins are emptied by means of a crane attached to the rear of a truck, which crane lifts the bucket and swings it over the truck body, when it is emptied by releasing the hinged bottom. The driver of the truck performs the whole operation of removing and dumping the bucket and can clean from 40 to 50 basins a day.

The Engineer and City Building

At the recent convention of the North Carolina Section of the American Waterworks Association the Mayor of Ashville, John H. Cathey, was asked to speak on the subject given in the above title, and in doing so paid a very graceful compliment to the municipal engineering profession. Among other things he said: "The waste in city building in the past for lack of competent engineering direction has been nothing less than criminal. No intelligent citizen objects to a proper expenditure of public funds, but the millions of dollars of the taxpayer's money that has been wasted for lack of engineering supervision has made the general public suspicious of nearly all large proposed civic improvements. They have seen so much of their money thrown away on pavements that go to rot in two or three years, on walls that will not stand up through the first long continued wet spell, on dams built of round stone that will not hold water, and on sewerage and water systems that are inadequate, that they are generally disgusted with the administration of all civic affairs.

"The present administration of Ashville is doing all in its power to win back the public confidence that is so vital in proper civic growth. With that aim in view we reorganized our engineering department as one of our first acts on coming into office. We found one city engineer and two assistants employed, and today we have three engineers and three assistants and an all-time clerk in the engineer's office. In addition to this, realizing that thousands of dollars had been wasted ignorantly rather than wilfully or criminally in improper paving, we went a step further and employed an expert company of engineers to supervise, analyze and inspect all future pavement laid in Ashville during our administration."

In addition, they employed, to advise them in the disposal of the city's garbage, a man recommended to them as the highest authority on the subject, and on his advice were completing an incinerator at a cost of about a hundred thousand dollars. The traffic problem is one which it seemed to Mayor Cathey should be solved by the engineer, and he believed, now that the engineer was taking it up, it would be so solved.

Recent Legal Decisions

PROTEST AGAINST PAVING IMPROVEMENT— "OWNERS OF MAJORITY OF FRONTAGE"

The Arizona Supreme Court holds, *McRoberts v. City of Phoenix*, 218 Pac. 994, that a protest against a proposed street improvement by a majority of the frontage owners does not necessarily comply with a statute requiring a protest by the owners of a majority of the frontage.

It is also held that the fact that a proposed paving will not connect with the paving in the business section, that the paving is not for the entire width of the street, and that the narrowing of the street will interfere with the use of plaintiff's premises for business purposes, does not state a cause of action for injunctive relief where, under a general statute authorizing paving improvements, the character and extent of the improvement are within the discretion of the city, and are not subject to review by the courts, unless it can be shown that such improvement is against the public interest and convenience.

HIGHWAY DISTRICT CHARGEABLE WITH KNOWLEDGE OF LIMITATION OF POWERS OF OTHER DISTRICT

The Idaho Supreme Court holds, *Deer Creek Highway Dist. v. Dounecq Highway Dist.*, 218 Pac. 371, that a highway district is chargeable with knowledge of the limitations of the lawful powers of other highway districts with which it contracts.

FACTORS IN DETERMINING EXTENT OF PAVING DISTRICT

The Montana Supreme Court, in a suit to prevent the creation of an improvement district by a city council, *Ricker v. City of Helena*, 218 Pac. 1049, says that it is a matter of common knowledge that the value and benefit of pavement depends upon its extent. Pavement of the street in front of a single lot or parcel, with none in front of the adjoining lots, would be of comparatively little benefit; whereas, if the pavement extends for a considerable distance, so as to secure easy and convenient approach, the benefit to the single lot is correspondingly greater. A council may take this into consideration in determining the necessity for the creation of a district and the extent of its boundaries.

SUIT ON CONTRACTOR'S BOND FOR GRAVEL TAKEN BY SUBCONTRACTOR FROM TOWNSHIP'S GRAVEL PIT

The Michigan Supreme Court holds, *Rolland v. Pakes*, 197 N. W. 525, that a township has the right to sue on the principal road contractor's bond for gravel taken from its gravel pit by a subcontractor and used in constructing a road where the contractor had received full payment from the state, although there was no valid contract for the gravel.

AUTHORIZED PUBLIC CONTRACT CANNOT BE ALTERED WITHOUT AUTHORITY

The California Supreme Court holds, *California Highway Commission v. Riley*, 218 Pac. 579, that when the state empowers an officer or board to enter

into a contract on its behalf, whereby it is to have certain rights and liabilities, and the officer or board has entered into such contract, no officer or board may thereafter act or speak for the state in the matter of such contract either for the enforcement or termination thereof, or increase or diminish the rights of the state or increase or reduce its liabilities thereunder unless he has been vested with authority so to do by express grant or clear implication.

MEASURE OF DAMAGES FOR BREACH OF ROAD CONTRACT

The Indiana Supreme Court holds, *Jackson v. State, ex rel. Board of Comrs. of Huntington County*, 142 N. E. 1, that the measure of damages for a breach of a road construction contract is the price at which the contract has been relet to the lowest bidder after due advertisement, where that has been done, in the absence of any showing that the advertisement and letting of the new contract was not fairly and honestly done, and it was not necessary to show that the work actually had been completed, and the price at which it was relet actually paid, in order to make out a cause of action.

CONTRIBUTIONS TO COST OF ROAD IMPROVEMENTS

The Arkansas Supreme Court holds, *Sanders v. Wilmans*, 254 S. W. 442, that the construction by road district commissioners, with funds of the district, of part of a road not authorized in the organization of the district, affords no ground for the annexation of territory under C. & M. Digest §§ 5426-5428, providing for the inclusion of lands without the boundaries benefited by an improvement. It is also held that city property, benefited by a rural road district improvement, can be included for the purpose of contributing, from the benefits received, to the cost of the improvement.

ROAD CONTRACTORS AGREEING TO TREAT CONTRACT AS COMPLETED CANNOT RECOVER FOR LOSS OF PROFITS

Road contractors sued for loss of profits where, on representations of the road improvement district that there were no more funds, they allowed the district to measure up the work done and pay therefor. The Arkansas Supreme Court, *Bradley & Carr v. Road Improvement Dist. No. 9*, 254 S. W. 817, held they could not recover, as they were not misled by the representations and had agreed to treat their contract as completed.

PAVING AT PARTIAL EXPENSE OF TOWNSHIP NOT AN INTERNAL IMPROVEMENT REQUIRING SUBMISSION TO ELECTORS

The Nebraska Supreme Court holds, *State v. Bone Creek Township*, 193 N. W. 767, that the paving of a public highway at the partial expense of a township is not a work of "internal improvement" within the meaning of that term as used in the constitutional limitation prohibiting "donations to any railroad, or other works of

internal improvement, unless a proposition so to do shall have been first submitted to the qualified electors thereof, at an election by authority of law."

PAVING CONTRACTOR'S GUARANTY TO KEEP WORK IN REPAIR

A paving contractor's maintenance bonds guaranteed the work performed under certain plans and specifications, and that at the end of the specified period the contractors should "deliver the work to the district in as good condition as when accepted, ordinary wear and tear excepted." The Arkansas Supreme Court holds *White Construction Co. vs. Arkansas-Louisiana Highways Imp. Dist.* 254 S. W. 820, that this necessarily referred to all work done by the contractors, except the cleaning of ditches and other items specified not to be considered as defects, and that the guaranty clause was not only a guaranty of workmanship and materials, but that the plans and specifications, when complied with, would result in an improvement that would last for the specified period, and be in the same condition at the expiration of that period as it was when originally completed and accepted, ordinary wear and tear excepted.

EFFECT OF NEW PAVING CONTRACT WITH CONTRACTOR AND SURETY ON BREACH OF ORIGINAL CONTRACT

The Arkansas Supreme Court holds, *United States Fidelity & Guaranty Co. v. Sellers*, 255 S. W. 26, that where a paving contractor breached his contract, and, with his surety, entered into a new one, suit on the old contract to be dismissed on completion of the work, the surety was a joint contractor with the contractor to complete the work as provided in the original contract between the contractor and the district.

EFFECT OF PAVING ORDINANCE PROVISION AS TO PAYMENT TO CONTRACTOR OF INCREASED FREIGHT RATES

A contract for street improvements to be made, as directed by ordinance, at the cost of the abutting owners, provided that any increase in freight rates should be paid to the contractor, but the city did not charge the abutting owners with such increase. The Kentucky Court of Appeals holds, *Lampton Burks v. Board of Council of City of Danville*, 255 S. W. 1029, that the city was not liable therefor to the contractor, the statute providing that the improvement of public ways shall be made at the exclusive cost of the abutting property owners, with certain exceptions therein provided for.

PROVISION FOR USE OF PATENTED PAVING MATERIAL HELD VALID

The Arizona Supreme Court holds that under section 1974, Civil Code of 1913, a contract for paving may provide for the use of patented material.—*Feland v. City of Phoenix*, 217 Pac. 65.

MEASURE OF DAMAGES FOR CONVERSION OF ROAD DISTRICT BONDS SOLD BELOW PAR.

The Texas Court of Civil Appeals holds, *American Surety Co., of New York v. Hill County*, 254 S. W. 241, that the measure of damages for the conversion by a road contractor and his surety

of road district bonds sold at less than par value is the value of the bonds with accrued interest. The burden was on defendants, if they wished to make the defense, to show that the county could have bought the bonds for less than par.

CONTRACT OBLIGATION TO REPAIR STREETS HELD NOT UNDER JURISDICTION OF COMMISSION

The Pennsylvania Supreme Court holds, *Borough of Swarthmore v. Public Service Commission*, 121 Atl. 488, that the control over services and facilities of public service companies given by the Public Service Company Law does not comprehend the power to relieve a street railway company of its obligation to keep a street in repair from curb to curb undertaken in consideration of permission to occupy the street with its tracks.

The Vermont Supreme Court, *Town of West Rutland v. Rutland Ry., Light & Power Co.*, 121 Atl. 755, while holding that the Public Service Commission, under G. L. 5045, 5050, has complete jurisdiction over the repair of streets between and adjoining street railway tracks, the commission does not have thereunder authority to modify or relieve the street railway from the requirements of its charter.

DISCRIMINATION IN ORDINANCE APPORTIONING COST OF PAVING IMPROVEMENT

The Kentucky Court of Appeals holds, *Board of Councilmen, City of Frankfort v. Morris*, 252 S. W. 142, that an ordinance providing that the city should pay the cost of a paving improvement between the tracks of a city railway and that the entire cost of paving streets not occupied by tracks should be assessed against the abutting owners, discriminated against the latter class and was invalid, under the Kentucky statute, Section 3450, requiring ordinances fixing the city's part of the cost of improvements to be uniform.

RECOVERY BY ROAD IMPROVEMENT DISTRICT OF OVERPAYMENTS TO CONTRACTOR

The Arkansas Supreme Court holds, *Gage & Spencer v. Road Improvement Dist. No. 3*, 252 S. W. 922, that a road contractor's surety, indemnifying the district against loss from the contractor's negligence and his failure to pay bills, or to complete the work in time, is not liable for overpayments made to the contractor through the engineer's fraud or gross mistake. Whether overpayments were made through such cause as to entitle the district to recover from the contractors was held a question for the jury.

ARKANSAS ROADS ACT REQUIREMENT OF PRESENTATION OF CLAIMS WITHIN NINETY DAYS CANNOT BE WAIVED

The Arkansas Supreme Court holds, *Western Randolph Road Improvement District v. First National Bank of Pocahontas*, 252 S. W. 928, that the provision of the Roads Act, 1919, No. 135, requiring the presentation of claims within 90 days cannot be waived by the commissioners or claimants by having a consent judgment entered in favor of a claimant. The claim is held completely barred by failure to comply with the statute, and cannot be revived by any promise on the part of the district to pay same.

Street Paving in 1924

The tables on the following pages give the amounts of each of the various kinds of pavements laid in the streets of nearly six hundred cities, with the cost, as reported by the city engineers or other officials.

As for fifteen years past, we are giving this month figures collected by questionnaire through the kindness of the nearly six hundred city engineers or other city officials who replied, showing the amount of each kind of pavement laid in their respective cities during the year 1924. In most cases there is given also the cost of the paving and the general items covered by the cost. Where only wearing course or wearing course and base are included, the costs per square yard in cities of the same section are more or less comparable. But where, as in a large number of cities, the costs include such items as resetting curb, building catch basins, regrading

sidewalks, building sewers and sewer connections, laying house services to the curb and building retaining walls, as well as doing an unstated amount of grading, the quotient obtained by dividing total cost by yards of pavement has no meaning whatever except as it may be used as a basis for assessments. The totals are, however, of some interest, we believe, as giving a general idea of the cost of combination street improvements of the nature described in each case. An effort has been made to give in the foot notes all the essential information concerning the figures that were found on the answered questionnaires.

SHEET ASPHALT AND ASPHALT CONCRETE LAID IN 1924

City & State	Sheet Asphalt Pavement		Asphalt Concrete		City & State	Sheet Asphalt Pavement		Asphalt Concrete	
	Amount	Cost	Amount	Cost		Amount	Cost	Amount	Cost
	sq. yds. or mi.		sq. yds. or mi.			sq. yds. or mi.		sq. yds. or mi.	
Alabama:					Iowa—(Continued)				
Anniston			81,549	\$246,870 ¹	Oelwein	61,000	164,700	....	....
Birmingham ..	43,860	\$110,194 ^a	129,660	285,942 ^a	Sioux City	0.49	24,838 ^f	....	....
Arkansas:					Waterloo	21,570	63,199	3,900	10,424
Fayetteville ...			50,000	145,000	Kansas:				
Texarkana	64,500	235,000 ^a	....	....	Hutchinson	4,386	15,911 ^b	40,074	128,748 ^b
California:					Kansas City....	....	31,083	99,061	....
Berkeley .....	....	....	1,198	3,020 ^d	Manhattan	5,996	22,882 ^f	....	....
Eureka .....	....	....	88,699	197,565 ^e	Wichita	19,580	76,120 ^f	82,441	257,675 ^f
Los Angeles....	186,022	561,142 ^a	88,834 ^{yd}	230,360 ^a	Kentucky:				
Ontario .....	....	....	63,740	98,200	Ashland	11,111 ^j	22,478	....	....
Sacramento .....	....	....	205,296	327,768 ^c	Covington	14,000	29,000 ^a	....	....
San Francisco...	54	137 ^a	219,232	575,223 ^a	Henderson	36,859	111,276 ^a	....	....
San Rafael.....	....	....	35,136	35,722	Owensboro .....	....	....	35,413	70,827
Santa Paula....	....	....	22,000	33,000	Louisiana:				
Vallejo .....	....	....	500	1,350 ^d	New Orleans....	1,740	6,415 ^e	9,790	30,214 ^a
Colorado:					Maryland:				
Denver .....	....	....	540,000	1,179,871	Salisbury	2,800	2,520 ^c	....	....
Trinidad .....	....	....	3,500	....	....	400	1,440 ^d	....	....
Connecticut:					Massachusetts:				
New Haven....	126,000	220,600	....	....	Barnstable ....	....	....	50,835	80,000
Delaware:					Boston	19,217	....	1,828 ^w	....
Wilmington ...	52,400	3,48 ^m	....	....	Brookline	8,065	30,084 ^e	....	....
Florida:					Lowell	8,386	....	33,442	....
Gainesville ...	....	....	20,000	60,000 ¹	Worcester .....	....	....	11,801	55,071
Jacksonville ...	16,390	56,300 ^a	10,825	46,500 ^f	Michigan:				
Sanford	145,000	261,000 ^a	....	....	Adrian	10,092	14,544	....	....
Georgia:					Ann Arbor	37,465	154,045 ^f	....	....
Decatur	7,020	4,024 ^j	32,000	58,716 ^a	Bay City	7,698	28,019	....	....
Illinois:					Detroit	1,249,375	5,961,886 ^a	....	....
Chicago	1,069,550	6,700,000 ^f	36,733	219,000 ^f	Grand Rapids...	16.1	909,200 ^a	....	....
Oak Park	0.4363	54,300 ^a	....	....	Highland Park..	29,735	164,223 ^f	....	....
Indiana:					Holland	38,100	111,500 ^b	....	....
Auburn	49,143	158,830 ^a	....	....	Kalamazoo	124,974	276,094	....	....
Bedford	10,000	41,000	....	....	Lansing	112,000	3,25-3,99 ^f	....	....
East Chicago...	19,038	41,013 ^a	2,000	5,000 ^a	Niles	4,720	2,05 ^{me}	21,400	2,95 ^m
Elkhart	3,600	14,214 ^f	....	....	Pontiac .....	....	....	9,000	1,65 ^{me}
Fort Wayne....	67,475	272,659 ^f	146,477	645,972 ^f	Royal Oak	28,831	124,861 ^f	....	....
Franklin .....	....	....	10,400	16,300 ^f	Ypsilanti	12,000	45,000 ^p	....	....
Gary	62,133	200,420 ^a	....	....	Minnesota:				
Huntington ...	6,103	10,391 ^j	....	....	Minneapolis ...	....	....	133,496	405,620 ^a
Indianapolis...	400,922	1,572,412 ^a	125,656	894,796 ^a	St. Paul	171,226	539,362 ^a	160,056 ^x	497,774 ^a
Iowa:					....	....	....	16,598 ^y	46,142
La Porte.....	60,605	239,389 ^a	....	....	Mississippi:				
Lebanon	11,000	23,600 ^c	....	....	Corinth	22,000	62,000	....	....
Mishawaka .....	....	....	11,814	42,286	Meridian	60,000	120,000	....	....
Newcastle .....	....	....	15,000	45,000 ^a	Missouri:				
Richmond	38,968	112,228 ^a	....	....	St. Louis	135,962	566,804	45,882	238,237
Rushville .....	....	....	15,000	50,000 ^b	Nebraska:				
South Bend....	107,265	336,675 ^a	3,672	13,826 ^a	Kearney .....	....	....	56,000	160,000 ^d
Vincennes	23,686	82,601 ^b	6,406	26,868 ^b	Lincoln	305,423	....	182,648	....
Washington....	73,941	182,942 ^a	....	....	Omaha	38,164	101,912 ^a	317,837	758,618 ^d
Kansas:					....	38,080	60,381 ^k	....	....
Cedar Rapids...	....	....	5,150	7,088	New Hampshire:				
Clinton .....	....	....	20,150	73,000	Franklin	9,000	....	....	....
Davenport	59,553	176,671 ^f	....	....	New Jersey:				
New Hampton...	....	....	30,000	76,000	Camden	145,380	447,050 ^a	93,576	199,330 ^a
Newton	47,000 ¹	1,55 ^m	....	....	Englewood	2,000	7,100	....	....
					Newark	201,000	876,000 ^f	....	....

SHEET ASPHALT AND ASPHALT CONCRETE LAID IN 1924—Continued

City & State	Sheet Asphalt Pavement			Asphalt Concrete			City & State	Sheet Asphalt Pavement			Asphalt Concrete		
	Amount	sq. yds. or mi.	Cost	Amount	sq. yds. or mi.	Cost		Amount	sq. yds. or mi.	Cost	Amount	sq. yds. or mi.	Cost
New Jersey—(Continued)							Pennsylvania—(Continued)						
New Brunswick	50,903		192,108	.....	.....	.....	Erie	143,340		544,077 ^a	.....	.....
Nutley	11,172		37,873 ^d	.....	.....	.....	Grove City	29,566 ^j		74,597 ^a	.....	.....
So. Orange	3,000		9,000 ^d	.....	.....	.....		22,280		120,754 ^a	.....	.....
Trenton	95,535		305,969 ^a	.....	.....	.....	Munhall	.....	.....	.....	2,633	7,926 ^k
West Hoboken	28,850		60,585 ^c	.....	.....	.....	Oil City	4,866		47,719 ^a	.....	.....
W. New York				8,300		18,675 ^c	Philadelphia	6.94 mi.		570,300 ^j	.....	.....
							Plymouth	20.2 mi.		1,440,000 ^a	.....	.....
New York:								1,545		9,500	.....	.....
Auburn	635		4,695 ^t	.....	.....	.....	Sharon	15,422		52,896 ^t	.....	.....
Buffalo	426,414		2,468,346 ^t	.....	.....	.....	York	12,732		50,269 ^a	.....	.....
Cortland	.....			39,000		102,000 ^t	South Carolina:					
Geneva	17,000			.....	.....	.....	Charleston	156,299		549,959	.....	.....
N. Y.—Manhattan	169,855		5.17 ^{mc}	.....	.....	.....	Tennessee:					
Niagara Falls	17,398		101,723 ^a	17,671		97,951 ^h	Bristol	.....		.....	12,100	44,000 ^h
Oneonta	14,000		1.60 ^{mc}	.....	.....	.....	Jackson	25,000		65,000 ^t	.....	.....
Rochester	103,180		307,476 ^d	.....	.....	.....	Johnson City	.....		.....	60,238	133,369
Schenectady	17,056		115,789 ^a	27,164		159,185 ^h	Texas:						
Utica	605		3.50 ^{md}	6,899		3.35 ^{md}	Houston	.....		.....	3,359 mi.	.....
North Carolina:							Vermont:						
Asheville	91,892		300,000	1,646		4,500	Burlington	20,143		41,373 ^a	.....	.....
Charlotte	111,989		323,636	146,152		392,000	Virginia:						
Durham	9,000		u	7,700		82,550 ^h	Danville	17,762		60,779	.....	.....
Greensboro	245,000		840,000 ^h	.....	.....	.....	Lynchburg	.....		.....	21,000	18,000 ^t
High Point	75,000		325,000	.....	.....	.....	Norfolk	100,000	2.25-3.75 mi.	.....	.....	.....
Winston-Salem	158,801		2.80 ^m	.....	.....	.....	Washington:					
North Dakota:							Seattle	2,945		.....	.....	.....
Fargo	.....		.....	12,038		51,242 ^t	Spokane	.....		.....	7,532	13,160 ^d
Ohio:							West Virginia:						
Akron	.....		.....	7.12 mi.		221,200 ^h	Morgantown	15,314		1.60 ^{mc}	.....	.....
Alliance	8,200		45,230 ^h	.....	.....	.....	Princeton	.....		.....	20,000	100,000 ^t
Columbus	283,300		1,460,000	22,600		110,000	Wisconsin:						
Dayton	63,359		229,936 ^h	.....	.....	.....	Fond du Lac	.....		.....	66,600	231,934 ^t
Dennison	10,320		49,371 ^a	.....	.....	.....	Kenosha	32,408		120,095	33,410	109,734
	6,940		18,465 ^j	.....	.....	.....	Milwaukee	32,900		91,674	35,400	102,248
Dover	17,325		71,322 ^a	.....	.....	.....	Wyoming:					
Hillsboro	16,000		3.05 ^{md}	.....	.....	.....	Cheyenne	124,558		2.88 ^{mc}	.....	.....
Lancaster	24,304		88,490 ^t	.....	.....	.....	Canada:					
Lima	82,221		462,891	.....	.....	.....	Moncton, N. B.	.....		.....	22,815	71,053 ^v
Marietta	15,495		83,171	.....	.....	.....	^a —Entire paving job, including engineering. ^b —Entire improvement. ^c —Wearing course alone. ^d —Wearing course and base. ^e —Wearing course, base and grading. ^f —Wearing course, base, grading and curb. ^g —Includes grading. ^h —Wearing course, base, grading, curb and drainage. ⁱ —Wearing course, base, grading and drainage. ^j —Resurfacing on old base. ^k —Surfacing old brick or concrete. ^l —Includes curb. ^m —Per square yard. ⁿ —Wearing course, base, grading, adjusting manholes, reinforced concrete over sewer trenches. ^o —Wearing course, base, grading, curb and 15% overhead. ^p —Wearing course, base, grading, curb, sidewalks and retaining walls. ^q —Includes grading, curb, catch basins, regrading sidewalks, and storm sewer connections. ^r —Included in the 82,550 under "asphalt concrete." ^s —Includes concrete base, grading, resetting manhole heads, curb and gutter, concrete headers, and tile underdrain. ^t —Tar concrete. ^u —3 in. on concrete base. ^v —2 in. on concrete base.					
Marion	8,527		48,500 ^t	.....	.....	.....				
Massillon	34,746		114,619 ^a	.....	.....	.....				
Newark	40,444		122,354 ^a	.....	.....	.....				
Niles	2,609		11,511 ^h	.....	.....	.....				
Salem				7,342		30,704 ^h							
Wooster	56,000		150,000	.....	.....	.....				
Oklahoma:													
Enid	.....		.....	{ 10,050		55,000 ^a						
				{ 12,000 ^j		18,000							
Muskogee	10,344		34,136	.....	.....	.....				
Oregon:													
Astoria	.....		.....	4,670		10,155 ^e						
Portland	.....		.....	{ 269,894		601,355 ^t						
				{ 102,191		151,524 ^c							
Salem	.....		.....	39,563		45,166						
Pennsylvania:													
Allentown	5,899		22,710 ^a	.....	.....	.....				
Duquesne	.....		.....	9,917		21,377 ^j						

ROCK ASPHALT AND BITUMINOUS MACADAM LAID IN 1924

City & State	Rock Asphalt			Bituminous Macadam			City & State	Rock Asphalt			Bituminous Macadam		
	Amount	sq. yds. or mi.	Cost	A—asphalt	T—tar	Cost		Amount	sq. yds. or mi.	Cost	A—asphalt	T—tar	Cost
Alabama:							Maryland:						
Florence	85,000		\$200,000 ^h				Salisbury				46,000T		69,000
California:							Louisiana:						
Berkeley				5,778A		6,650 ^c	New Orleans	21,160		73,254 ^a			
Napa				2,000A		3,100	Massachusetts:						
Ontario				22,000A		11,000	Andover				4,197T		1,57 ^m
Redlands				20,000A		28,000	Arlington				14,326A		21,281
San Rafael				15,144A		13,516	Boston				42,415A		
Santa Paula				10,000A		6,000 ^a	Brockton				10,100A		18,000 ^a
Upland				16,000A		4,320	Brookline				26,858T		
Connecticut:							Dartmouth				5,360A		8,991 ^a
Bridgeport				14,000A		24,000 ^a					32,060T		32,600 ^a
Greenwich				1,817A		5,088 ^a	Grafton				0.75A		18,000
New Haven				2,500A		4,500	Greenfield				26,295A		
Wallingford				7,000A		1.85 ^m	Hudson				6,200A		15,000
Florida:							Lee				3,200T		3,000 ^m
St. Augustine				4.0A			Lowell				3,292A		
Sanford				20,000A		22,000 ^c	Lynn				80,149A		2.75 ^m
Georgia:							Northampton				10,000A		20,000 ⁱ
Decatur				12,000A			Southbridge				16,000T		28,000
Illinois:							Stoneham				1,200T		2,500
Chicago				106,000A		645,000 ^t	Newton				31,990A		54,684
Harvard	0.5						Webster				10,822T		12,590 ^t
Mt. Vernon	4,000		12,000 ^h				Weymouth				7,035A		14,000
Indiana:							Winchester				13,700A		20,650 ^a
Boonville	2,889		2.65 ^{mc}				Worcester				7,671T		34,776
Franklin	4,392		9,820 ^t				Michigan:						
Hammond				2,491A		4,982 ^t	Stambaugh				5,537A		9,573 ^c
Richmond				11,411T		2.85 ^{mc}	Minnesota:						
Rushville				5,600A		10,300 ^h	Brainerd				7,222T		11,124 ^a
Kansas:							St. Paul				2,717A		3,559 ^a
Kansas City	58,019		191,123				Missouri:						
Kentucky:							Boonville				1,000T		1,500
Ashland				21,997T		130,403 ^a	Maplewood				2,746A		9,911
Maine:							Marshall				4,704A		7,297 ^c
Augusta				5,000T		6,050	Nevada	1,000		1,450 ^c			
Portland				19,323A			St. Louis	51,061		169,005			

ROCK ASPHALT AND BITUMINOUS MACADAM LAID IN 1924—Continued

Rock Asphalt— Amount				Bituminous— Macadam		Rock Asphalt— Amount				Bituminous— Macadam	
City & State	Sq. yds. or ml.	Cost	A— Amount	T— Cost		City & State	Sq. yds. or ml.	Cost	A— Amount	T— Cost	
Missouri—(Continued)						Pennsylvania—(Continued)					
Sedalia .....	.....	.....	5,020A	6,375 ^c		Towanda .....	.....	.....	8,160T	5,673 ^c
Springfield .....	.....	.....	5,451A	4,088 ^c		Uniontown	750	1,312	.....	.....
			24,596T	7,000 ^c		Warren	5,907	34,734 ^h	.....	.....
New Hampshire						Rhode Island					
Franklin .....	.....	.....	2,800T	.....		Woonsocket .....	.....	.....	47,260A	.....
Keene	3,572A	1,459 ^{ia}		Tennessee					
New Jersey						Alcoa	1,400	3,050 ^u	.....	.....
Belleville .....	.....	.....	28,308A	.....		Bristol .....	.....	.....	2,200T	3,050 ^h
Englewood	58,000A	116,000		Texas					
Nutley .....	.....	.....	9,486A	15,755 ^c		Corsicana .....	.....	.....	1,000A	2,000 ^h
Phillipsburg .....	.....	.....	8,000T	14,000 ^c		Dallas	13,396	57,587 ^f	.....	.....
Rutherford .....	.....	.....	40,150A	66,889 ^c		Houston	10,928mi.	.....	2,382mi.A	.....
Somerville	3,560T	7,400 ^c		Vermont					
So. Orange .....	.....	.....	8,000A	17,000		Burlington .....	.....	.....	0.72mi.A	11,394 ^u
Summit .....	.....	.....	5,000T	9,000		Rutland	2,500	3,000 ^c	4,000A	4,200 ^c
Wallington	30,700T	39,000 ^p		Virginia					
			23,305A	39,214		Staunton .....	.....	.....	25,000A	20,000 ^u
New York						Suffolk	6,083	9,286	.....	.....
Auburn	500T	1,000 ^v		Wisconsin					
East Rochester .....	.....	.....	2,960T	14,000 ^h		Baraboo .....	.....	.....	3,300T	3,900
Hempstead .....	.....	.....	18,271A	.....		Eau Claire .....	.....	.....	2,000T	3,927
Saranac Lake .....	.....	.....	4,000A	7,600		La Crosse .....	.....	.....	1,000A	1,250
Watertown .....	.....	.....	3,214A	3,593 ^u		Milwaukee .....	.....	.....	277,400T	192,500
			26,537T	36,582 ^c		Wausau .....	.....	.....	2,000T	2,000 ^u
North Carolina						Canada					
Winston-Salem ..	10,786	2.80 ^{mf}	.....	.....		Moncton, N. B. ....	.....	.....	19,982T	1,199
Ohio						^a Entire paving job, including engineering. ^b Entire improvement. ^c Bituminous paving alone. ^d Paving, grading and curb. ^e Includes grading. ^f Paving, grading, curb and drainage. ^g Paving, grading and drainage. ^h Resurfacing. ⁱ Includes cobble sub-base. ^m Per square yard. ⁿ Done by municipal forces. ^o 3 in. of penetration tar macadam on old macadam base. ^p Includes 12 in. of earth excavation, 4 in. concrete base and 2 cts. for paint inspection. ^q Includes labor and material, not repair of street before application. ^r Wearing course, base and grading; labor \$3 for 9 hrs.; city owns stone for crushing. ^s 13,270 sq. yd. of 3 in. to 4 in. top over macadam; 7,954 sq. yd. of 5 in. to 6 in. on new foundation, and 5,100 sq. yd. complete, including 14 in. to 18 in. clay excavation and placing 4 in. layer of gravel and 8 in. to 10 in. Telford base. ^t Includes grading, curb, catch basins, regrading sidewalks, and storm Warrenite-Bitultithic					
Columbus	4,900	6,360	.....	.....					
Dayton	4,420	21,495 ^t	.....	.....					
Delaware	1.25	101,254 ^h	.....	.....					
Elyria .....	.....	.....	4,200A	3,620 ^j						
Niles .....	.....	.....	2,202T	6,489 ^t						
Sylvania .....	.....	.....	18,218A	65,983 ^b						
Oklahoma											
Shawnee	100,000	600,000 ^b	.....	.....					
Pennsylvania											
Berwick .....	.....	.....	15T	.....						
Chambersburg ..	.....	.....	12,776T	7,593 ^u						
Clairton	20 tons	400	.....	.....					
Greensburg	1,205	2,732 ^u	.....	.....					
Hazleton .....	.....	.....	86,465T	12,313 ^u						
Jersey Shore ..	.....	.....	4,500	9,000						
New Brighton ..	8,640	12,563 ^j	.....	.....					
Philadelphia .....	.....	.....	6.66 ml.A	195,000 ^u						

OTHER BITUMINOUS PAVEMENTS LAID IN 1924

City and State	Kind of pavement	Amount	Cost
Alabama			
Birmingham	Warrenite-Bitullithic	47,322	\$115,562 ^a
Florence	Warrenite-Bitullithic	3,000	5,000 ^h
California			
Bakersfield	Warrenite-Bitullithic	49,460	148,055 ^c
Hawthorne	Willite	275,330	652,600
Los Angeles	Warrenite-Bitullithic	127,400	425,950 ^a
Visalia	Warrenite-Bitullithic	23,501	60,751 ^t
Colorado			
Boulder	Warrenite-Bitullithic	21,391	84,402 ^h
Pueblo	Warrenite-Bitullithic	22,000	2,23 ^m
Trinidad	Warrenite-Bitullithic	18,761	52,152 ^h
Connecticut			
Bridgeport	Warrenite-Bitullithic	9,000	18,000 ^u
Greenwich	Warrenite-Bitullithic	9,153	53,181
Florida			
Jacksonville	Willite	22,200	101,600 ^t
Illinois			
Chicago	Willite	21,200	130,000 ^t
Crystal Lake	Warrenite-Bitullithic	26,076	2,50 ^{md}
Indiana			
Princeton	Emulsified Asphalt	18 miles	40,000
Iowa			
Davenport	Warrenite-Bitullithic	53,917	170,517 ^t
Mt. Pleasant	Bitullithic	20,593	57,661
Kansas			
Kansas City	Warrenite-Bitullithic	19,050	78,064
Louisiana			
New Orleans	Warrenite-Bitullithic	63,830	234,269 ^c
Massachusetts			
Boston	Warrenite-Bitullithic	110,552	
Brookline	Warrenite-Bitullithic	21,431	55,499 ^c
Northbridge	Warrenite-Bitullithic	2 miles	1,25 ^{mc}
Michigan			
Escanaba	Warrenite-Bitullithic	60,000	120,000
Mississippi			
Meridian	Warrenite-Bitullithic	60,000	144,000
Missouri			
Carthage	Amiesite	2,628	3,416
St. Louis	Warrenite-Bitullithic	112,872	585,853
	Willite	114,793	535,065
Montana			
Billings	Warrenite-Bitullithic	35,111	91,805 ^d
		11,124	28,032 ^c
Helena	Warrenite-Bitullithic	17,500 ^x	45,000 ⁱ
Kalispell	Warrenite-Bitullithic	10,348	33,928 ^t
New Jersey			
Nutley	Warrenite-Bitullithic	220	440 ^c
So. Orange	Asphalt block	800	400
New Mexico			
Albuquerque	Warrenite-Bitullithic	118,855	335,000 ^a
New York			
Batavia	Warrenite-Bitullithic	15,117	88,235 ^a
	Asphalt block	4,014	28,937 ^a
City and State Kind of pavement Amount Cost			
East Rochester	Willite	13,859	20,000 ^h
Johnson City	Warrenite-Bitullithic	26,325	108,310 ^h
Lockport	Warrenite-Bitullithic	5,078	22,025 ^c
N. Y. Manhattan	Asphalt block	1,542	6,29 ^{mg}
Niagara Falls	Asphalt block	14,430	105,551 ^h
N. Tonawanda	Warrenite-Bitullithic	13,300	46,056 ^h
Oneida	Warrenite-Bitullithic	6,042	32,009 ^t
Rensselaer	Asphalt block	8,900	40,495
	Warrenite-Bitullithic	25,000	43,250 ^d
Rochester	Willite	59,690	100,279 ^d
	Asphalt block	2,480	7,440 ^d
Utica	Warrenite-Bitullithic	88,150	3,50 ^{md}
	Asbestos Bitullithic	1,131	3,85 ^{md}
N. Carolina			
Asheville	Warrenite-Bitullithic	8,036	23,586
Fayetteville	Warrenite-Bitullithic	92,500	418,000 ^h
Winston-Salem	Bitullithic	185,553	2,80 ^{mn}
Oklahoma			
Muskogee	Willite	800	
Oregon			
La Grande	Warrenite-Bitullithic	91,965	295,592 ^a
	Oiled macadam	1,908	3,320 ^t
Portland	Asph.-concr. redress on macadam	102,191	157,524 ^t
Pennsylvania			
Allentown	Amiesite	11,494	47,123 ^c
	Warrenite-Bitullithic	7,750	29,200 ^c
Altoona	Warrenite-Bitullithic	18,804	69,604 ^t
Connellsville	Willite	8,254	31,250
Hazleton	Amiesite	6,762	33,570 ^t
Lebanon	Warrenite-Bitullithic	7,119	43,931 ^h
Nazareth	Amiesite	6,611	32,000 ^d
Philadelphia	Redressed Gran. blk	9.2 ml.	440,600 ^u
Punxsutawney	Warrenite-Bitullithic	14,386	52,454 ^h
Steelton	Warrenite-Bitullithic	974	3,896
Uniontown	Warrenite-Bitullithic	6,024	31,716
Waynesburg	Willite		24,000
Texas			
Amarillo	Willite	18,771	50,000
Dallas	Warrenite-Bitullithic	114,636	454,623 ^t
	Willite	210,825	827,833 ^t
Houston	Warrenite-Bitullithic	7,205 ml.	
Longview	Amiesite	30,000	51,000
Washington			
Olympia	Warrenite-Bitullithic	400	1,000 ^c
Wenatche	Warrenite	44,989	131,264 ^a
Wyoming			
Sheridan	Warrenite-Bitullithic	52,639	212,845 ^h

^aEntire pavement job, including engineering. ^bEntire improvement. ^cBituminous paving alone. ^dPaving, grading and curb. ^eIncludes grading. ^fPaving, grading, curb and drainage. ^gPaving, grading and drainage. ^hResurfacing. ⁱIncludes cobble sub-base. ^mPer square yard. ⁿDone by municipal forces. ^o3 in. of penetration tar macadam on old macadam base. ^pIncludes 12 in. of earth excavation, 4 in. concrete base and 2 cts. for paint inspection. ^qIncludes labor and material, not repair of street before application. ^rWearing course, base and grading; labor \$3 for 9 hrs.; city owns stone for crushing. ^s13,270 sq. yd. of 3 in. to 4 in. top over macadam; 7,954 sq. yd. of 5 in. to 6 in. on new foundation, and 5,100 sq. yd. complete, including 14 in. to 18 in. clay excavation and placing 4 in. layer of gravel and 8 in. to 10 in. Telford base. ^tIncludes grading, curb, catch basins, regrading sidewalks, and storm

STONE BLOCK AND BRICK PAVEMENTS LAID IN 1924

City & State	Stone Block			Brick			City & State	Stone Block			Brick		
	Amount	Sq. yds. or mi.	Cost	Amount	Sq. yds. or mi.	Cost		Amount	Sq. yds. or mi.	Cost	Amount	Sq. yds. or mi.	Cost
Alabama							New York—(Continued)						
Birmingham .....	....	....	....	20,201		\$83,652 ^a	Niagara Falls .....	....	....	....	20,558		135,111 ^b
California:							N. Tonawanda .....	....	....	....	725		3,262 ^c
San Francisco .....	....	....	....	223		1,200 ^c	Oneonta	1,720	12,476 ^c	....	....	....	....
Colorado							Rensselaer	8,500	26,180	....	....	....	....
Trinidad .....	....	....	....	21,632		104,059 ^b	Utica	2,107 ^p	....	....	7,419 ^p	....	....
Connecticut							North Carolina						
Ansonia .....	....	....	....	3,755		11,152 ^j	Asheville	6,612 ^w	24,813	....	....	....	....
Derby .....	....	....	....	1,807		8,232 ^k	Winston-Salem ..	15,273 ^r	3,50 ^m	....	....	....	....
New Haven	2,100		7,500	....		....	Ohio						
Delaware:							Ashtabula .....	....	....	....	3,700		24,118
Wilmington	5,650		4.16 ^{mz}	5,550		5.44 ^{mz}	Bellaire .....	....	....	....	4,545		24,191
Florida							Columbus .....	....	....	....	42,000		240,000
Fernandina .....	....	....	....	6,200		19,200 ^a	Dayton .....	....	....	....	21,404		50,447 ^r
Jacksonville .....	....	....	....	5,930		24,650 ^c	E. Youngstown ..	....	....	....	12,000		4.10 ^m
Orlando .....	....	....	....	125,000		282,225	Elyria .....	....	....	....	7,706		47,255 ^b
Illinois							Hillsboro .....	....	....	....	1,800		3,000 ^{ma}
Canton .....	....	....	....	1,367		7,549	Jackson .....	....	....	....	14,125		53,500 ^c
Carbondale .....	....	....	....	21,327		112,889 ^b	Lancaster .....	....	....	....	11,382		54,861 ^r
Chicago	12,600		90,000 ^c	....		....	Lima .....	....	....	....	47,699		177,191
Duquoin .....	....	....	....	40,395		204,926 ^a	Logan .....	....	....	....	33,000		125,000 ^c
Mt. Vernon .....	....	....	....	13,000		56,000 ^b	Marion .....	....	....	....	6,718		25,192 ^a
Normal .....	....	....	....	16,772		80,553 ^a	Massillon .....	....	....	....	6,593		35,877 ^a
Waukegan .....	....	....	....	14,095		65,000 ^a	Newark .....	....	....	....	1,241		2,829 ^r
Indiana							Salem .....	....	....	....	4,730		....
Indianapolis	2,246 ^w		15,837 ^d	3,625		15,949 ^d	Troy .....	....	....	....	5,000		....
Lebanon .....	....	....	....	1,340		4,500 ^e	Wooster .....	....	....	....	3,000		....
Linton .....	....	....	....	1,200		4,600 ^b	Zanesville .....	....	....	....	4,935		24,600 ^d
Noblesville .....	....	....	....	4,488 ^v		....	Oklahoma						
Richmond .....	....	....	....	801		4,000 ^{me}	Muskogee .....	....	....	....	500		....
South Bend .....	....	....	....	16,610		54,742 ^a	Ponca City .....	....	....	....	26,986		143,254 ^a
Iowa							Pennsylvania						
Cedar Rapids .....	....	....	....	10,657		38,854	Altoona .....	....	....	....	4,379		17,000 ^t
Centerville .....	....	....	....	4,718		17,221	Avoca .....	....	....	....	6,400		44,000
Davenport .....	....	....	....	1,769		9,301 ^r	Clairton .....	....	....	....	5,113		32,000 ⁱ
Iowa City .....	....	....	....	35,200		146,500 ^b	Connellsville .....	....	....	....	18,901		76,587 ^a
Keokuk .....	....	....	....	2,456		9,486 ^r	Duquesne .....	....	....	....	12,397		54,489 ^d
Mt. Pleasant .....	....	....	....	21,112		69,249	Ebensburg .....	....	....	....	5,000		....
Kansas							Ellwood City .....	....	....	....	2,500		8,625 ^d
Chanute .....	....	....	....	28,000		54,000 ^j	Greensburg .....	....	....	....	680		6,464 ^a
Kansas City .....	....	....	....	3,835		14,707	Greenville .....	....	....	....	817		3,866 ^c
McPherson .....	....	....	....	5,086		22,190 ^h	Huntingdon .....	....	....	....	12,000 ^c		52,500 ^c
Manhattan .....	....	....	....	7,385		22,081 ^r	New Brighton .....	....	....	....	206		....
Newton .....	....	....	....	18,250		71,000	New Castle .....	....	....	....	8,500		44,625
Parsons .....	....	....	....	1,650		5,828 ^r	North Braddock ..	....	....	....	16,075		106,861
Salina .....	....	....	....	37,400		152,000 ^r	Philadelphia ..	0.045 mi. { 11.1 mi. ^a	6,500 ^e	0.27 mi	6,356		36,615 ^r
Wichita .....	....	....	....	1,317		5,574 ^a	Philadelph.		927,600 ^e		21,800 ^e		....
Kentucky							Oil City .....	....	....	....	9,169		68,193 ^u
Ashland .....	....	....	....	26,905		227,896 ^a	Sharon .....	....	....	....	14,363		67,622 ^r
Louisiana:							Wilkinsburg	0.04mi. { 0.08	2,651		1.2		9,525 ^r
New Orleans .....	....	....	....	43,630		100,643 ^a	Williamsport ...	....	....	....	10,000		43,968 ^j
Maine							Rhode Island						3.76 ^{mo}
Gardiner	6,137		17,244 ⁱ	....		....	Woonsocket	2,617	....	....	....	....	....
Portland	21,808		....	....		....	Tennessee						
Rockland	528		2,287 ^a	....		....	Jackson .....	....	....	....	11,000		40,000 ^c
Maryland							Texas						
Salisbury .....	....	....	....	800		4,880 ^d	Amarillo .....	....	....	....	58,873		....
Massachusetts							Corsicana .....	....	....	....	100,000		358,000 ^b
Boston	117,994		....	1,585		....	Dallas .....	....	....	....	10,918		47,362 ^r
Lowell	24,105		....	....		....	Houston .....	....	....	....	1.109mi.		....
Lynn	10,727		3.00 ^m	....		....	Virginia						
Worcester	2,412		14,447	....		....	Lynchburg	3,177	8,000 ^r	....	1,920		7,500 ^r
Michigan							Suffolk .....	....	....	....	8,557		6,161 ^v
Grand Rapids ..	....	....	....	0.26mi.		22,200 ^h	Norfolk	20,000	1.25 ^{mg}	....	....	....	....
Kalamazoo .....	....	....	....	6,023		23,797	Washington						
Pontiac .....	....	....	....	4,000		4.80 ^{md}	Seattle	12	....	....	8,113		....
Minnesota							Wenatchee	475	6,505	....	8,823		....
Minneapolis	14,927		71,439 ^a	31,577		130,465 ^a	West Virginia						
Rochester .....	....	....	....	16,500		56,100 ^r	Clarksburg .....	....	....	....	5,000		32,000 ^r
St. Paul .....	....	....	....	144,444		579,220 ^a	Fairmont .....	....	....	....	4,500		10,000 ^v
Mississippi							Morgantown .....	....	....	....	4,810		5.75 ^{ma}
Laurel .....	....	....	....	25,000		77,500 ^d	Wisconsin						
Missouri							La Crosse .....	....	....	....	31,138		115,500
St. Louis	16,214		86,272	7,324		46,070	Milwaukee	9,200	56,873	....	1,400		7,400
Springfield .....	....	....	....	5,000		18,250 ^e							
Trenton .....	....	....	....	911		3,550							
Nebraska													
Fairbury .....	....	....	....	41,000		158,135 ^r							
Lincoln .....	....	....	....	11,940		....						
New Jersey													
Camden	9,335		31,920 ^a	....		....				
Newark	17,800		121,000	....		....				
Nutley	11,617		42,676 ^a	....		....				
Rutherford	200		1,250 ^a	500		1,500 ^c							
Trenton	24,900		126,682 ^a	4,590		22,978 ^a							
New York													
Amsterdam .....	....	....	....	1,951		5,677 ^a							
Buffalo .....	....	....	....	22,531		148,865 ^c							
Corning .....	....	....	....	1,127		7,367 ^r							
Cortland .....	....	....	....	1,000		4,000 ^r							
Jamestown .....	....	....	....	54,653		212,000 ^b							
Lockport .....	....	....	....	10,171		48,725 ^r							
New York (Man.)	174,221		8.72 ^{mz}	....		....				

^aEntire pavement, including engineering. ^bEntire improvement. ^cSurface course alone. ^dSurface and base. ^eSurface, base and grading. ^fSurface, base, grading and curb. ^gIncludes grading. ^hSurface, base, grading, curb and drainage. ⁱSurface, base, grading and drainage. ^jResurfacing on old base. ^k550 sq. yds. on old base, balance includes 5 in. concrete base. ^lOld granite blocks renapped and relaid on old base; city furnished gravel. ^mPer square yard. ⁿReclipped blocks between trolley tracks; 5 in. concrete base \$11,617 additional. ^oLaid by railroad in railroad strip. ^pDurax block re-cut. ^qSurface, base, grading, curb, gutters, drainage, and replacing water connections with lead pipe. ^rWork done by municipal forces. ^sSurface, base, grading, curb, sidewalks and retaining walls. ^tBrick relaid. ^uDurax. ^vGrading, curb and paving on slag. ^wOn sand or slag base. ^xRedressed block.

CONCRETE PAVEMENT LAID IN 1924—Continued

City and State	Reinforced Concrete		Not Reinforced	
	Amount Sq. yds. or mi.	Cost	Reinforce- ment, Wt. per 100 sq. ft. Sq. yds. or mi.	Amount Sq. yds. or mi.
Alabama:				
Birmingham	56,000	170,000	40 lb. mesh	8,274
Florida	48,000	140,000	Fabric
Troy
Arkansas:				
Blytheville	208,000	461,760	12,000
Fayetteville	28,711V
Pine Bluff
California:				
Bakersfield	24,234
Berkeley	67,131
Orange	1,386
Los Angeles	72,900
Napa	131,214g
Redlands	1,145,213
Sacramento	\$3,228,631c
San Francisco	15,600
San Rafael	4,500
Upland	2,900
Vallejo	4,563
Colorado:				
Denver	54,107
Longmont	152,886c
Pueblo	13,228
Connecticut:				
Ansonia	5,000
Bristol	3,064
Greenwich	5,688
New Haven
Wallingford
Florida:				
Jacksonville
Illinois:				
Benton	9,725	40,000	19,000
Canton	6,479	26,816
Chicago
Indiana:				
Clinton	13,377
Harrisburg	5,081
Kewanee
Madison	24,200	109,000	52 lb. fabric	30,304V
Monmouth
Mt. Vernon	20,000	80,000h	42 lb. fabric	30,000
Normal	5,580	24,224a	40 lb. fabric
Oak Park
Pontiac	2,850	13,500a	40 lb. mesh	11,54 ml.
Robinson	16,000	55,000
Waukegan	117,000	600,000a	45 lb. mesh
West Chicago	61,000V
Indiana:				
Bedford	6,660
Boonville	19,395
Brazil	15,000
Connersville	16,250
East Chicago	57,000	189,970	50 lb. fabric	13,400
Elkhart	41,661
Fort Wayne	2,126
Frankfort	28,553	100,294p	59 lb. mesh
Gary	35,197	197,607f	34 lb.
Greencastle
Hammond	55,802	167,407f	28 lb. bars	1,500
Indianapolis	226,986	681,757z
Kendallville
Lebanon	5,090	15,700g	50 lb. fabric	36,500h
Linton	10,940
Mishawaka	40,000i
Muncie	86,626V
Newcastle	12,718
Noblesville	10,000
.....	9,840
Indiana:				
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CONCRETE PAVEMENT LAID IN 1924—Continued

City and State	Amount Sq. yds. or mi.	Reinforced Concrete		Amount Sq. yds. or mi.	Cost	Not Reinforced	
		Reinforce- ment, Wt. per 100 sq. ft.	Sq. yds. or mi.			Amount Sq. yds. or mi.	Cost
Minnesota:							
Brainerd	17,195	33.7 lb. bars	.....	.....	38,146a	33.7 lb. bars	.....
Chisholm	6,500	32 lb. fabric	.....	.....	20,000g	32 lb. fabric	.....
Cloquet	10,216	.....	.....	.....	40,022f	.....	.....
Fairmont	13,445	.....	.....	.....	37,938k	.....	.....
Minneapolis	6,000	.....	.....	.....	12,661	.....	39,556g
Rochester	162,957	30 lb. bars	.....	.....	15,600a	30 lb. bars	.....
St. Paul	381,549	1/2-in. bars,	.....	.....	381,549g	1/2-in. bars,	12,430
Virginia	12,042r	3 x 2 ft.	.....	.....	34,792g	3 x 2 ft.	6,221V
Mississippi:							
Clarksdale	.....	.....	.....	.....	.....	.....	14,500g
Missouri:							
Boonville	.....	.....	.....	.....	.....	.....	40,000
Cape Girardeau	.....	.....	.....	.....	18,000	.....	225,000
Carthage	.....	.....	.....	.....	3 mi.	.....	46,734
Independence	.....	.....	.....	.....	17,752	.....	58,000
Maplewood	39,398	.....	.....	.....	22,000	.....	.....
Nevada	.....	48.3 lb. fab.	.....	.....	104,827	48.3 lb. fab.	26,000c
St. Louis	27,386	.....	.....	.....	108,500	.....	300,100
Sedalia	.....	.....	.....	.....	.....	.....	112,000
Springfield	.....	.....	.....	.....	.....	.....	17,540
Trenton	21,120	.....	.....	.....	50,688	.....	74,600
Montana:							
Billings	.....	.....	.....	.....	.....	.....	.....
Kalispell	.....	.....	.....	.....	2,033	.....	4,641
Nebraska:							
Fremont	19,292	.....	.....	.....	200	.....	500f
Holdrege	.....	.....	.....	.....	.....	.....	.....
Lincoln	.....	28 lb.	.....	.....	41,047	28 lb.	.....
Omaha	.....	.....	.....	.....	145,428	.....	.....
New Hampshire:							
Keene	1,000	Fabric	.....	.....	.....	Fabric	.....
New Jersey:							
Belleville	4,602	.....	.....	.....	2,850f	.....	.....
Camden	.....	.....	.....	.....	.....	.....	.....
Cape May	7,979	.....	.....	.....	.....	.....	.....
Millville	20,461	40 lb. fabric	.....	.....	18,063g	40 lb. fabric	.....
Phillipsburg	3,600	60 lb. fabric	.....	.....	63,000h	60 lb. fabric	.....
South Orange	15,000	60 lb. fabric	.....	.....	12,500g	60 lb. fabric	.....
South River	0.5 mi	.....	.....	.....	3,000	.....	.....
Trenton	7,173	.....	.....	.....	20,000g	.....	.....
Wallington	18.5	.....	.....	.....	17,742g	.....	.....
West Hoboken	1,136	.....	.....	.....	65	.....	.....
New York:							
Amsterdam	13,680	.....	.....	.....	3,976	.....	.....
Auburn	16,455	50 lb. fabric	.....	.....	23,320g	50 lb. fabric	.....
Batavia	13,871	63 lb. fabric	.....	.....	67,445f	63 lb. fabric	.....
Corning	56,400	45.2 lb. fab.	.....	.....	65,916a	45.2 lb. fab.	.....
Geneva	700	59 lb.	.....	.....	.....	59 lb.	.....
Glens Falls	10,348	4,000c	.....	.....	4,000c	.....	.....
Herkimer	8,811	40 lb.	.....	.....	32,833f	40 lb.	.....
Jamestown	.....	%-in bars	.....	.....	.....	%-in bars	.....
Little Falls	9,085	73 lb.	.....	.....	39,243h	73 lb.	.....
Lockport	15,753	80 lb.	.....	.....	64,239h	80 lb.	2,868
Mamaroneck	4,727 cu.yd	41 lb.	.....	.....	61,962f	41 lb.	.....
Niagara Falls	.....	wire mesh	.....	.....	91,073	wire mesh	3,618
Norwich	4,227	Fabric	.....	.....	.....	Fabric	.....
Rensselaer	10,500	50 lb. mesh	.....	.....	17,851c	50 lb. mesh	.....
Rochester	11,860	65 lb. mesh	.....	.....	33,600	65 lb. mesh	.....
Schenectady	13,834	35 lb. mesh	.....	.....	20,598c	35 lb. mesh	.....
Scotia	10,271	35 lb. weld-	.....	.....	40,084v	35 lb. weld-	.....
Solvay	27,000	ed wire	.....	.....	32,095g	ed wire	8,816
Utica	12,973	%-in bars	.....	.....	93,000f	%-in bars	.....
		Bar & mesh	.....	.....	2,75mc	Bar & mesh	.....
			.....	.....			5,700b
			.....	.....			17,074h
			.....	.....			24,275g

CONCRETE PAVEMENT LAID IN 1924—Continued

Reinforced Concrete		Not Reinforced	
Amount Sq. yds. or mi.	Cost	Reinforce- ment, Wt. per 100 sq. ft.	Amount Sq. yds. or mi.
Tennessee:			
Alcoa	.....	.....	15,728
Bristol	.....	.....	17,000
Jackson	.....	.....	21,000
Kingsport	.....	.....	8,000
Texas:			
Houston	.....	.....	0.139
Vermont:			
Barre	29,348c	.....	.....
Burlington	.....	.....	.....
Rutland	23,552g	.....	.....
Virginia:			
Hampton	.....	.....	.....
Lynchburg	7,740	26 lb. fabric	12,186
Salem	.....	.....	1,500
Suffolk	.....	.....	23,301
Washington:			
Aberdeen	.....	.....	.....
Olympia	.....	.....	.....
Port Angeles	5,140	.....	.....
Seattle	13,378	.....	.....
Spokane	200	.....	.....
Wenatchee	.....	.....	.....
West Virginia:			
Clarksburg	22,096	56 lb. fabric	.....
Fairmont	.....	.....	.....
Morgantown	15,050	2.75mc %-in bars, 18 in. c to c	6,500
Moundsville	.....	.....	.....
Wisconsin:			
Eau Claire	22,268	30 lb.	.....
Fond du Lac	16,500	.....	.....
Green Bay	.....	.....	.....
Janesville	167,342	42 lb. fabric	1,023
Kaukauna	.....	.....	16,785v
Kenosha	45,490	.....	.....
La Crosse	2,103	.....	.....
Lake Geneva	14,102	40 lb. fabric	.....
Manitowoc	15,000	33 to 48 lb.	.....
Milwaukee	.....	.....	.....
Sheboygan	72,158	.....	.....
Two Rivers	.....	.....	.....
Waukesha	.....	.....	.....
Wausau	1,300	.....	.....
Wisconsin Rapids	11,000	.....	.....
Wyoming:			
Casper	28,138	30 lb.	.....
Sheridan	.....	.....	.....
Notes:			
V-Vibroplithic. A-Entire paving job, including engineering. b-Entire im- provement. c-Concrete only. f-Concrete, grading and curb. g-Includes grading. h-Concrete, grading, curb and drainage. i-Concrete, grading and drainage. k-Concrete, grading, curb and gutter, storm drains and inlets. l- Concrete, grading, curb, catch basins, regading sidewalks, storm water con- ductions. m-Per square yard. n-Laid by municipal forces. p-Includes grad- ing, curb, sidewalk, sewer catch basins and manholes. r-In alleys. s-In concrete at \$2.43, 8-in. at \$2.70. t-Includes grading, but not cement. u-In- cludes grading, curb and 15% overhead. v-Includes grading, curb, and sewer and water laterals. w-Grading, curb, gutter, drainage, replacing, curb, and sewer and water laterals. x-Grading, curb, gutter, drainage, replacing, curb, and sewer and water laterals. y-Grading, curb, gutter and sidewalks. z-Includes grading, curb, gutter and parkways. z-Includes grading, curb, gutter, storm sewers, catch basins, manholes and laterals.			

V—Vibrolithic. A—Entire paving job, including engineering. b—Entire improvement. c—Concrete only. f—Concrete, grading and curb. g—Includes grading. h—Concrete, grading, curb and gutter, sidewalks and inlets. i—Concrete, grading, curb and gutter, storm drains and inlets. j—Concrete, grading, curb, catch basins, regrading, sidewalks, storm water connections. k—Concrete, grading, curb, catch basins and manholes. l—Inlets, curb, sidewalk, sewer, catch basins and manholes. m—Inlets, curb, sidewalk, sewer, catch basins and manholes. n—Laid by municipal forces. p—Includes grading, curb and gutter, storm water connections. q—Includes grading, curb and gutter, storm water connections. r—Inlets, curb, sidewalk, sewer, catch basins and manholes. s—Inlets, curb, sidewalk, sewer, catch basins and manholes. t—Includes grading, curb and gutter, storm water connections. u—Includes grading, curb and gutter, storm water connections. v—Includes grading, curb and gutter, storm water connections. w—Includes grading, curb and gutter, storm water connections. x—Includes grading, curb and gutter, storm water connections. y—Includes grading, curb and gutter, storm water connections. z—Includes grading, curb and gutter, storm water connections.

WATERBOUND MACADAM AND GRAVEL LAID IN 1924—Continued

City and State	Water-bound macadam		Gravel	
	Amount Sq. yds. or miles	Cost	Amount Sq. yds. or miles	Cost
Pennsylvania:				
Berwick			2 mi.	...
Hazleton				30,359
Jersey Shore... 73,000		5,600		
Monongahela .. 3,293		15,331f		
So. Carolina:				
Chester			6,500	1,625
So. Dakota:				
Mitchell			13,747	5,207
Rapid City			4,000	5,000
Tennessee:				
Clarksville 15,000		5,000		
Texas:				
Amarillo			2,721	...
Brownwood			46,933	4,250
Corsicana			50,000	25,000
Houston			17,576	...
Port Arthur			1.51 mi.	8,000
Weatherford			2 mi.	...
Utah:				
Tooele			31,680	2,851
Vermont:				
Burlington			0.42 mi.	...
Virginia:				
Lynchburg 43,800		28,000		...
Staunton	4,000	2,500		...
Suffolk			20,251k	22,276
Washington:				
Aberdeen			7.1 mi.	104,644r
Wisconsin:				
Janesville			0.5 mi.	...
Lake Geneva			16,000	6,000
Manitowoc			25,000	...
Wausau			1,200	700g
Wyoming:				
Casper			16,300	36,200c
Canada:				
Moncton, N. B.			8,000	2,200

a—Entire pavement, including engineering. c—Wearing course only. f—Includes grading, curb and gutter. g—Includes grading. h—Includes grading, curb and drainage. i—Includes grading and drainage. j—Includes grading, curb and gutter, sidewalks and drainage. k—Surface treated. l—By municipal forces. m—Per square yard. n—Cubic yards. p—Reshaping, water binding and oiling. r—Includes grading, curb and storm sewers. s—Includes basins and draining.

OTHER BITUMINOUS PAVEMENTS LAID IN 1924

City and State	Kind of pavement	Amount Sq. yd. or ml.	Cost
Pueblo, Colo.	Shale	10 ml.	\$1,08n
Jacksonville, Fla.	Flor. lime rock	2,975	4,900
Pontiac, Mich.	Creso'd wd. blk.	17,000	2,86m
Minneapolis, Minn.	Creso'd wd. blk.	120,063	586,072g
Man. Boro., N. Y.	Creso'd wd. blk.	656	7,74md
Asheville, N. C.	Ber sonite	12,234	14,681
Altoona, Pa.	Creso'd wd. bk.	2,157	14,450f
Philadelphia, Pa.	Redres'd gr. blk.	9.2 mi.	440,600
Houston, Tex.	Shell	7,098 ml.	...
Burlington, Vt.	Cinders	0.192 ml.	...
Rutland, Vt.	Creso'd wd. bk.	750	3,100c

c—Wearing course only. d—Wearing course and base. f—Wearing course, base, grading and curb. g—Includes grading. m—Per square yard. n—Per cubic yard.

Tarring Streets in Berwick

Some of the methods employed by the Borough of Berwick, Pa., in the use of tar on its street pavements were described in "Public Works" for March, 1924, by Boyd Trescott, engineer for the borough. Mr. Trescott sends us information this year concerning certain changes made which have produced even more satisfactory results.

In applying tar to the streets, this had former-

ly been done by the firm which furnished it at an additional cost of 3c. per gallon. This method required the Borough to have ready for application, whenever a carload of tar might arrive, a sufficient area of streets to use the entire amount and sometimes, because of rain or other conditions, the streets were not in the best of condition for tarring. In some cases it was found, after all the material had been applied, that there were places that should have a second application to make a good job. It was, therefore, decided to look into the matter of storing tar to be used as needed. Early in 1924 one of the railroad companies offered a location for a tank alongside their tracks at a nominal rental. At the same time the firm which had the contract for furnishing the tar for 1924 offered the borough free of charge a tank carried by a car which the railroad companies had condemned. These offers were accepted. The borough then bought a good distributor for applying the oil, mounted on a truck chassis which could be used for general purposes when not desired for oiling. The tank was located on the railroad site and can be filled from the railroad tank car by gravity. From the borough's tank the tar can be pumped into the distributor as needed.

In order to minimize the obstruction to traffic, in some cases one-half the street was oiled at a time. As soon as the oil had been applied a light coat of pea gravel or $\frac{1}{4}$ " stone was spread by driving trucks along the edge of the fresh oil and spreading the material directly from the truck. During the season 90,000 gallons were bought and about 76,000 gallons applied to the streets of the borough, the balance being used on outlying districts adjacent to the borough. About 15 miles of streets were covered from curb to curb, the width ranging from 30 to 55 ft., thus leaving no gravel edges to crumble away and destroy the tarred roadway. New streets received as much as one gallon to the yard, which was reduced to as little as one-quarter of a gallon in the case of some streets which had been treated previous years.

Under the method employed this year the cost to the borough for labor was about \$2.00 per 1,000 gallons as against the 3c. per gallon paid in former years, giving a saving of \$280 per car, and as nine cars were applied this year the saving was almost enough to cover the cost of the oiler tank complete above the cost of the chassis, which is used for other purposes as well.

Mr. Trescott reports that where Tarvia has been applied for two or three years, the gravel is penetrated to a depth of as much as three inches and, although some of the streets are used continuously for heavy trucking, there are absolutely no signs of breaking down under traffic; nor do the roads break up in the spring when the frost goes out.

He also describes the use of Tarvia KP in widening out a brick pavement which had been built in 1915 with a width of 14 feet and a 12-inch concrete curb on each side. This had be-

(Continued on page 74)

CEMENT SIDEWALKS LAID IN 1924

City and State	Amount sq. ft. or mi.	Cost	City and State	Amount sq. ft. or mi.	Cost	City and State	Amount sq. ft. or mi.	Cost
Alabama:			Michigan:			Oklahoma:		
Florida	45,000	.....	Ann Arbor	132,000	18 cts.b	Ponca City	5,000	900
Florence	63,000	\$10,000	Battle Creek	41,310	5,366	Sapulpa	1,500e	20 cts.b
Arkansas:			Bay City	24,160	5,083	Vinita	1,000e	800
Fayetteville	60,000	14,500	Dowagiac	30,113	.....	Wagoner	900e	810
California:			Hastings	25,015	2,751	Oregon:		
Bakersfield	89,217	21,109a	Holland	1,800	630	Ashland	18,000	3,500
Berkeley	30,000	5,400	Ironwood	8,000	2,000	Astoria	44,356	10,327
Hawthorne	1,592,800	398,200	Kalamazoo	20,000	2,700	Baker	2,132,676	22 cts.b
Los Angeles	888,050	1,711,890	Lansing	30,000	15 cts.b	Eugene	264,000	60,000
Orland	5,000	750	Mt. Pleasant	1,200e	720	La Grande	111,968	21 ctsb
Redlands	19,000	3,100	Muskegon Heights	87,243	11,850	Oregon City	8,900e	8,900
Visalia	100,000	20,000	Owosso	53,937	9,329	Portland	518,000	.....
Colorado:			Port Huron	2 mi.	10,000	Salem	162,484	21,123
Monte Vista	2,700	675	Royal Oak	18 mi.	85,536	Pennsylvania:		
Connecticut:			Traverse City	13,500	1,500	Berwick	22,500	15½ cts.b
Bristol	29,958	7,626	Ypsilanti	54,000	10,800	Chambersburg	50,589	20 cts.b
Putnam	25,000	7,000	Minnesota:			Clairton	11,250	4,000
Florida:			Brainerd	9,414	1,597	Du Bois	10,800	.....
Fernandina	2,250	550	Cloquet	32,226	4,512	Ellwood City	9,000	1,980
St. Augustine	5 mi.	.....	Ely	30,000	.....	Freeland	10,359	5,900
Sanford	48,000	9,600	Fairmont	5,000	900	Hanover	16,200	2,916
Idaho:			Minneapolis	1,513,485	201,433	Huntingdon	4,500	.....
Burley	3,375	376	Rochester	66,600	13,000	New Brighton	25,000	12,500
Illinois:			St. Paul	736,824	114,207	South Carolina:		
Chicago	7,603,200	.....	Virginia	16,031	3,527	Charleston	563,796	101,107
Clinton	43,560	22.5 cts.b	Mississippi:			Chester	792	197
Kewanee	22,650	4,700	Clarksdale	21,120	5,280	Greenwood	30,000	4,500
Metropolis	45,000	20 cts b	Corinth	14,400	2,560	Orangeburg	4,050	742
Mt. Vernon	7 mi.	.....	Laurel	36,000	6,600	Spartanburg	630,000	125,000
Normal	14,720	2,944	Missouri:			South Dakota:		
Oak Park	0.03 mi.	260	Cape Girardeau	1 mi.	5,300	Madison	2,000	360
Indiana:			Independence	22,000	4,500	Mitchell	27,603	4,730
Blacknell	4,500	1,000	Nevada	10,000e	.....	Rapid City	28,000	7,000
Brazil	70,000	17,000	Springfield	9,200e	6,810	Tennessee:		
East Chicago	110,000	23,000	Trenton	1,000	170	Alcoa	18,270	4,575
Elkhart	77,034	17,430	Montana:			Bristol	41,400	7,300
Fort Wayne	491,040	97,315	Billings	26,056	6,058	Johnson City	6,000e	.....
Greencastle	40,000	8,000	Kalispell	16,223	3,302	Texas:		
Hammond	227,710	45,542	Nebraska:			Brownwood	31,680	5,068
Indianapolis	698,785	261,200	Lincoln	29,156	.....	Corsicana	5.5 mi.	23,000
Kendallville	9,000	1,400	Scottsbluff	10,000	1,500	Dallas	998,855	179,793
Lebanon	32,000	4,480	New Hampshire:			Houston	54.2 mi.	.....
Linton	9,000	1,750	Keene	0.6 mi.	4,181	Longview	0.5 mi.	2,112
Mishawaka	145,581	.....	New Jersey:			Port Arthur	18,095	.....
Muncie	123,237	22,443	Camden	30,000	6,450	Weatherford	800e	.....
Noblesville	19,555	3,911	Englewood	13,000e	13,000	Vermont:		
Princeton	2 mi.	.....	Nutley	2,452f	5,109	Burlington	13,082e	17,027
Richmond	3.42 mi.	23 cts.b	Ohio:			Virginia:		
Rushville	4,000	.....	Rutherford	20,000	4,777	Danville	43,200	9,900
Vincennes	2 mi.	17,000	South River	½ mi.	2,500	Harrisonburg	13,147	1,802
Washington	60,000	12,800	Trenton	2,461	5,751	Lynchburg	77,400	16,000
West Lafayette	8,100	1,200	Wallington	41,689	10,197	Salem	9,000	1,500
Winchester	5,000	20 cts.b	West Hoboken	5,708	1,712	Staunton	16,803	2,500
Iowa:			New York:			Suffolk	46,908	7,968
Cedar Rapids	27,600	5,508	Amsterdam	945,000	.....	Washington:		
Le Mars	5,400	.....	Auburn	25,000	6,500	Aberdeen	75,744	14,076
Sioux City	9.90 mi.	38,458	Buffalo	199,649	32,942	Olympia	18,000	3,000
Kansas:			Corning	3,550	639	Seattle	107,900	195,000
Hutchinson	33,129	4,307	East Rochester	13,000	2,600	Spokane	14,270	15,700
Manhattan	24,047	3,575	Johnson City	17,453	3,490	Yakima	21,474	.....
Parsons	1,000	760	Niagara Falls	72,594	20,286	West Virginia:		
Salina	3,000	450	Ogdensburg	632	1,577	Clarksburg	90,000	20,000
Kentucky:			Oneonta	22,364	6,068	Morgantown	63,000	2,75 cts.
Corbin	70,000	33,000	Rensselaer	31,500	8,200	Wisconsin:		
Covington	10,000	.....	Schenectady	10,715	32,918	Beloit	10,000	1,400
Paducah .....	.....	80,000	Solvay	3 mi.	83,000a	Clintonville	1,000e	800
Louisiana:			Utica	7.7 mi.	25 cts.b	Eau Claire	90,000	9,000
Lake Charles	2 mi.	4,000	North Carolina:			Lake Geneva	8,100	500
New Orleans	29,280	.....	Charlotte	55,096	90,000	Marinette	15,066	1.25
Maine:			Greensboro	26,000	.....	Milwaukee	930,000	250 ft.
Augusta	0.91 mi.	27,331	Winston-Salem	1,019,376h	1.70c	Waukesha	45,000	15 cts.b
Maryland:			North Dakota:			Wausau	190,080	14 cts.b
Salisbury	9,000	1,800	Dickinson	3,150	599	Wyoming:		
Massachusetts:			Fargo	1.53 mi.	8,321	Casper	12.4 mi.	78,000
Adams	12,183	.....	Grand Forks	11,800	2,050	Cheyenne	8,016	23 cts.b
Arlington	75,510	24,729	Ohio:			Sheridan	16,050	3,210
Barnstable	5,400	2,000	Akron	8,405e	9,519	Footnotes:		
Boston	91,313	.....	Columbus	189,500	44,000	a—Includes curbs. b—Per square foot.		
Brookton	6,300	1,600	Conneaut	2 mi.	17 cts.b	c—Per square yard. d—Cost of 9 different jobs ran from \$1.70 to \$2.57 per sq. yd.; 4-in. walk, including all grading and shoulders between walk and gutter. The \$2.67 includes curb 20 in. deep. e—Lineal feet. f—4-in. no cinder or stone base. g—6-in. no cinder or stone base. h—Granolithic. i—Stone. j—Includes curb and gutter.		
Greenfield	47,457	10,947d	East Youngstown	24,000	.....		
Hudson	8,100	2,300	Elyria	922	4,166			
Lowell	19,146	.....	Other:					
Lynn	206,721	2,800	Tamilton	14,330i	.....		
Newton	108,073	43,293	Jackson	39,000	26,741j			
Northampton	18,000	6,000	Logan	1,000	1,800			
Northbridge	0.5 mi.	2,350	Marietta	6.2 mi.	.....		
Southbridge	2,000e	3,500	Logan	18,000	14,950			
Stoneham	1,800	500	Massillon	7,500	5,000			
Taunton	63,000	26,616	Newark	53,251	31,938			
Webster	19,818	10,497	Troy	10,130	1,520			
Winchester	25,200	7,050	Wooster	2,500	350			
Worcester	1.02 mi.	22,199						

come too narrow for present traffic and the curb had broken down in places so that it was becoming dangerous. In widening the pavement, the curb, where it had not already broken down, was removed to a depth of about 3 inches below the top surface of the brick and the dirt for a width of 3 feet was graded down to the same depth. Tarvia KP was mixed with small gravel in the yard and hauled to the street, spread and rolled with a 10-ton roller, giving a wearing coat 3 inches thick and three feet wide on each side of the brick pavement. A coat of small stone was then applied and covered with a light coat of Tarvia B by using the manifold on one side of the oiler only. This oil served as a seal coat on the new material and was extended over onto the brick a short distance so as to keep the water out from the joint between the new and the old pavement. Nearly a mile of street was treated in this way and has stood up under use by the heaviest trucks. The tar-concrete was mixed in a concrete mixer, the stone or gravel being first placed in the mixer and then the tar poured in from a bucket. A little experience taught the proper amount of tar to use so that it would set up and not ravel and yet not be soft enough to push under traffic.

Engineering in Plumbing

Investigations have been made of the hydraulics and pneumatics of house plumbing by the Engineering Experiment Station of the University of Illinois under the direction of Harold E. Babbitt, associate professor of Municipal and Sanitary Engineering, "with a view of obtaining definite information concerning the positive and negative pressures found in soil stacks, waste pipes, traps and vent pipes, and also concerning the limitations of rates of discharge and the capacities of waste pipes and soil stacks."

A description of the method of conducting the investigations and the conclusions therefrom are contained in Bulletin No. 143 of the Engineering Experiment Station, from which the following paragraphs have been abstracted. Most

of the conclusions reached are of interest almost exclusively to plumbers and house builders, but some concern, directly or indirectly, sanitary and city engineers.

"The maximum change of level of the water in a trap resulting from the application of pressure is approximately the same for all diameters of traps, provided the trap is sufficiently large to render negligible the effect of friction in retarding the movement of the water.

"The maximum rate at which water will flow down a 4-inch soil stack without creating uncontrollable pressures in a plumbing system is high. A 4-inch soil stack will probably take all of the water that would be delivered to it in a 5-story building, a 3-inch soil stack will probably take all of the water that would be delivered to it in a 3-story residence, and 2-inch pipe is unsuitable to be used as a soil stack.

"The effect of the length of the house drain on the pressures in a plumbing system need not be considered in plumbing design.

"If a house trap, either vented or unvented, is used at the end of the house drain, the pressures throughout the plumbing system are increased. It is, therefore, concluded that a house trap should not be used in a plumbing system."

"The closure of the top of the soil stack or the closure of vent pipes will result in such increases in pressure as to endanger the seals in traps. Soil stacks and vent pipes should, therefore, be designed to prevent the possibility of becoming stopped up.

"It is reasonably safe to use unvented traps of any style with a 2-inch depth of seal in 1-story or 2-story residences containing a single bathroom and the normal number of laundry and kitchen fixtures connected to one 3-inch soil stack if precautions be taken to prevent the destruction of the seal of trap by self siphonage, the submergence of the outlet to the house drain, the stoppage of the top of the soil stack, and also to prevent the pressures created by the discharge of traps into a horizontal waste pipe from breaking the seal in other traps connected to the same waste pipe."

Finishing Pavement at Street Intersection



FINISHING CONCRETE PAVEMENT AT STREET INTERSECTION.

In using a mechanical finisher for striking off a concrete pavement on a city street, the curb is commonly used as the track on which the wheels of the finisher travel. At a street intersection, however, the curb is missing on one or both sides. Here a special track may be placed temporarily across the intersecting street in line and grade with the curb and the finisher travel on this. The photograph shows such track across a 24-foot roadway. The corners around the curves and the junction of the two pavements are finished by hand.